WOMEN IN CHEMISTRY

A Study of Professional Opportunities

THE BUREAU OF VOCATIONAL INFORMATION

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WOMEN IN CHEMISTRY

A Study of Professional Opportunities

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SOUTHERN BRANCH

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INTRODUCTION

To the woman who in her college course finds the subject of chemistry intensely fascinating there comes the question, "If I should choose to make chemistry my life work, what are the fields open to me, what further preparation shall I need, and what are the opportunities for success and advancement?" The recent progress of the science of chemistry in America, and especially the wartime demands, opened new and untried fields to the woman investigator.

Fortunately for the student of chemistry now looking about for guidance as to her choice of work after graduation, there has been compiled in the following pages a careful survey of the various kinds of positions available in chemistry and the border fields, particularly bacteriology and physiology. Adapting to its work the method of the scientific laboratory, the Bureau of Vocational Information has gathered data from every source on the opportunities in chemistry now open to women. With this data assembled and analyzed, some very definite conclusions have been drawn, which will serve as a useful guide to the prospective entrant into industrial or institutional positions.

The subject has been so thoroughly covered that these pages may be studied with interest by a far larger group than those for whom they have been especially prepared. For the college woman about to choose an occupation, there is presented a comprehensive, conservative description of existing conditions, interspersed with sage advice as to the difficulties to be encountered, and sound philosophy as to the benefits to be derived from devotion to a science whose goal is service to humanity.

CHARLES H. HERTY, *President*,
Synthetic Organic Chemical Manufacturers Association
Formerly Editor, Journal of Industrial and Engineering Chemistry.

SOURCES OF INFORMATION

The information upon which the following report is based has come, by means of interviews, questionnaires and letters, from women chemists themselves; from chief chemists, research chemists, laboratory directors and other executives in industry; from heads of laboratories, chemists and pathologists in laboratories for medical analysis and research; from organizations, and from departments of chemistry in colleges and universities. These various sources are itemized as follows:

Information from women chemists, through interviews, questionnaires and letters:

In educational institutions	69
In medical laboratories	43
In industrial laboratories	116
In government laboratories	26
In allied fields and miscellaneous	32
	286

Information from university departments, scientific journals, scientific societies, and fellow-chemists in regard to additional women chemists:

In educational institutions	70
In medical laboratories	18
In industrial laboratories	83
In government laboratories	18
In allied fields and miscellaneous	42
Graduate students	24
Not allocated	113
	368
As above	286
Total	654

Geographic distribution of 654 women chemists:

Alabama	1	Delaware	15
California	28	District of Columbia	34
Colorado	4	Florida	1
Connecticut	14	Georgia	1

Illinois	66	North Dakota	1
Indiana	4	Ohio	27
Iowa	17	Oregon	2
Kansas	7	Pennsylvania	62
Kentucky	4	Rhode Island	2
Louisiana	3	South Dakota	1
Maryland	26	Tennessee	6
Massachusetts	74	Texas	2
Michigan	10	Vermont	1
Minnesota	11	Virginia	1
Missouri	8	Washington	5
Montana	1	West Virginia	1
Nebraska	1	Wisconsin	22
New Hampshire	3	Canada	6
New Jersey	41	Hawaii	1
New York	134	Unknown	5
North Carolina	1		

Information from industry, through interviews, questionnaires and letters from:

Chief chemists	101
Research chemists	14
Consulting chemists	15
Directors of laboratories	16
General superintendents, chemical superintendents, works managers, employment departments, presidents, vice-presidents, secretaries	45
	191

Information from medical laboratories, through interviews and letters, from heads of laboratories, chemists, pathologists, 19.

Information from organizations as follows:

American Chemical Society
National Research Council, Information Department
The Chemists' Club
U. S. Bureau of Education
U. S. Bureau of the Census
U. S. Departments of Agriculture, Commerce, Interior, Navy, Treasury, War
American Ceramic Society
American Society of Biological Chemists
Hospital Library and Service Bureau
Bureau of Occupations of Women's University Club, Los Angeles
Appointment Bureau, Women's Educational and Industrial Union, Boston

Professional and Business Women's Section, State-City Employment Service, Cleveland
Collegiate Bureau of Occupations, Denver
Vocation and Placement Bureau for Business and Professional Women, Pasadena
Women's Employment Service, Pittsburgh.

Information from departments of chemistry, through interviews, questionnaires and letters, in 50 colleges and universities; from catalogues of 177 colleges and universities.

ACKNOWLEDGMENTS

To all those chemists and executives enumerated above, who contributed in generous measure the results of their experience as a basis for this report and to the representatives of organizations, colleges and universities who gave valuable information, the staff of the Bureau of Vocational Information acknowledge their great indebtedness.

The American Association of University Women appointed a committee of women chemists to cooperate with the Bureau of Vocational Information in preparing the section of this report on Training, Part III. The committee consisted of the following members:

Representing teaching: Dr. Emma Carr, Professor of Chemistry, Mount Holyoke College; Dr. Louise McDanell Browne, formerly Associate Professor of Home Economics, Goucher College; Dr. Annie Louise Macleod, Associate Professor of Chemistry, Vassar College; Dr. Ruth O'Brien, Associate Professor of Textile Chemistry, Iowa State College; Dr. Marie Reimer, Professor of Chemistry, Barnard College; Dr. Mary M. Rising, Instructor of Chemistry, University of Chicago; Dr. Mary Swartz Rose, Associate Professor of Household Arts, Teachers College; Dr. Ethel M. Terry, Assistant Professor of Chemistry, University of Chicago; Miss Helen Updegraff, Department of Chemistry, University of Illinois.

Representing medical research: Dr. Ida Rolf, Rockefeller Institute for Medical Research.

Representing industry: Miss Emma Crandell; Miss Helen Clark Gillette, Central Research Laboratory of the Union Carbide and Carbon Research Laboratories, Inc.; Miss C. M. Hoke, Jewelers' Technical Advice Company; Miss Kathryn Holden, recently with the Nestles Food Company; Mrs. Glenola Behling Rose, E. I. Du Pont de Nemours Company; Miss Elizabeth Weirick, Textile Testing Laboratory of Sears, Roebuck & Company.

The valuable cooperation of this committee is acknowledged with sincere gratitude.

The staff of the Bureau wish to acknowledge indebtedness also and express appreciation for valuable criticism and help, to Dr. Edgar Fahs Smith, University of Pennsylvania, Dr. Charles H. Herty of the Synthetic Organic Chemical Manufacturers Association, Dr. Edwin E. Slosson of Science Service, and Dr. Marie Reimer of Barnard College, who read the manuscript; to Dr. Arthur T. Little of Boston, who read the section of the report on positions in laboratories for industrial analysis, development and research; to Dr. Louise McDanell Browne of Brooklyn, Dr. William McPherson of Ohio State University, Dr. Mary E. Holmes of Connecticut College, and Dr. Henry C. Sherman of Columbia University, who read the section of the report on positions in educational institutions; also to Dr. Stanley Benedict, Professor of Chemistry, Medical College, Cornell University; Dr. Katherine Blunt, Chairman of the Department of Home Economics, University of Chicago; Miss Clotilde Grunsky, Associate Editor, Journal of Electricity and Western Industry, San Francisco; Dr. Dorothy A. Hahn, Professor of Chemistry, Mt. Holyoke College; Miss Callie Hull, Research Information Service, National Research Council; Dr. L. F. Kebler, Chief of Drug Division, Bureau of Chemistry, U. S. Department of Agriculture; Miss Lois Woodford, Synthetic Organic Chemical Manufacturers Association.

Women in Chemistry

PART I.

CHEMISTRY AS A VOCATION

Chemistry in Modern Life. Chemistry is more intimately connected with life than is any other science. It was the war which brought us a sweeping realization of its importance, when the scientists of the country were enrolled for "chemical warfare," and defense against it in adequate gas masks, when they developed our production of munitions and built smoke screens for our battleships. The lack of dyes and of important medicines, the struggle to provide the nitrates necessary for munitions and for soil nourishment forced a recognition of the uneven progress of the development and application of chemistry in different countries and of our need to develop our own chemical industries.

The pressure of this need produced employment not only for all chemists but for many who were but partly trained and in many cases ill-equipped for the responsibilities of their positions. In the following period of business depression these were the first to be released. Although many trained chemists have also suffered from lack of employment, those who are highly qualified have been retained.

The future development of American industry is intimately bound up in a proper supply of *adequately trained chemists.* The dependence of industry upon pure science has been conclusively proven; the greatest developments in the applications of science have come as the result of long, painstaking experimentation. It is too easy to overlook our indebtedness to chemistry in everyday life—as we wash our hands with *soap,* choose garments of any desired *color,* whether it be an immaculate bleach or a Tyrean purple, cook our food in *aluminum* and season it with *sugar* and a variety of *flavors,* read our books of *paper* printed with *ink,* breathe the fragrance of exotic *perfumes,* enjoy the comfort of *rubber* tires, build our railroads of *steel,* our houses of *concrete* and our windows of *glass.* Chemistry is the basis of innumerable manufacturing processes.

Not only is manufacture in practically every line dependent upon chemistry for the organization and development of its processes, but in agriculture also progress depends upon the understanding and application of the laws of this fundamental science of the transformation of matter, which govern as well the conversion of the components of the soil and of the air into corn and cotton and the numerous basic supplies of mankind. With increasing knowledge comes greater control of the quality and quantity of production.

Perhaps the greatest service and promise of chemistry is in its relation to medicine, a relation which dates back to the earliest days of chemistry in Egypt, but which has just entered upon a most important stage of progress.[1] Biochemists are turning to a comprehensive study of the human body, cooperating with physicists and biologists, in the hope of ultimately expressing all the major facts of the material side of life in their own exact terms, and thereby giving to medicine the control characteristic of an exact science.

For two reasons it is evident that superior preparation is requisite for successful work in chemistry in these important future developments. In the first place, the progress of chemistry has been so extensive that an undergraduate course can no longer satisfactorily prepare the student for important scientific service. Not only do the universities emphasize this, but industries have recognized it as well in establishing fellowships for graduate study.

In the second place, chemistry as a vocation represents a comparatively small professional group in which the increase in numbers has been steady but moderate. There is reason to expect a more rapid growth than in the past with the return of industry to full production and with the development of medical research. An unusual number of college students are majoring in chemistry, however, and there are chemists now unemployed. There is, therefore, every reason to expect a stronger competition than ever before, in which the *best* qualifications will win; for science is one field in which there is always a check for all work done and successful competition is based solely on ability and honest results.

Women Chemists. The extent of chemistry as a vocation is approximately indicated by various statistics. The census of 1910 reported 16,126 chemists, assayers and metallurgists; in 1920 this number had increased to 32,941. It is impossible to determine from

[1] See The Future Independence and Progress of American Medicine in The Age of Chemistry; the report of a committee of the American Chemical Society, published by The Chemical Foundation, 1922.

census reports the proportion of trained chemists in this group; the enrollment of scientific societies is suggestive of what this number may be. The National Research Council has listed 2,172 research chemists. The American Society of Biological Chemists, to membership in which anyone is eligible who has conducted and published a meritorious original investigation in biological chemistry, had 216 members in 1920. American Men of Science records about 1,770 chemists. The American Chemical Society had in 1921 some 15,000 members. During the war this society had enrolled from 17,000 to 18,000 names of persons eligible for chemical service. The secretary of the society suggests a rough estimate of some 22,000 chemists in the United States.

Of this number the proportion of women probably approximates 4 to 5 per cent. Of the 16,126 chemists, assayers and metallurgists reported in the census of 1910, 579 or 3.5 per cent were women. The census of 1920 records 32,941 chemists, assayers and metallurgists of whom 1,714 or 5.2 per cent are women. Of 2,172 research chemists listed by the National Research Council, 70 or 3.2 per cent are women; of 216 members of the American Society of Biological chemists, 7, or 3.2 per cent are women. Among the 1,770 chemists included in American Men of Science, nearly 3 per cent are women. Of the 15,000 members of the American Chemical Society, about 3 per cent are women.

In 1920 there were conferred in American Universities 96 doctorates in chemistry. Of these, 9, or 9.3 per cent, were conferred upon women. In 1921, of the 134 doctorates in chemistry, 13 were conferred upon women; this was 9.7 per cent of the whole number. It is encouraging to note that of the women entering this profession so large a proportion is securing the superior preparation which is proving to be essential for any progress.

In the course of preparing this report specific information was received concerning some 660 women chemists. If from a basis of 17,000 to 18,000 enrolled chemists it is safe to estimate some 22,000 chemists in the United States, the enrollment of 660 may justify the estimate of about a thousand women chemists, or from 4 to 5 per cent of the total.

Although their number is small, women are not newcomers in the field of chemistry. It was a book by an American woman, "Conversations on Chemistry," written in 1813 by Mrs. J. Marcet, of New Haven, which contributed to the great Faraday's first interest in chemistry, according to his own statement, when as an apprentice bookbinder he snatched moments from his work to read the books which came to be bound in his employer's shop.

Rachel L. Bodley, professor of chemistry at the Woman's Medical College of Pennsylvania, was chosen as a vice-president of the centennial anniversary meeting of American chemists in 1874. This meeting was the forerunner of the American Chemical Society.

Nor have the achievements of the few women in chemistry been small. Mme. Curie is internationally known and reverenced as the greatest of living chemists.

In America it is recognized that some of the most important contributions to biochemistry, especially to the chemistry of nutrition, have been made by women—Dr. Mary Swartz Rose at Teachers College, Dr. Icie Gertrude Macy at the University of California, Dr. Alice Rohde Davis and others. Dr. Amy L. Daniels is research professor in nutrition in the Child Welfare Research Station at the University of Iowa, which was organized primarily for investigation in the field of child betterment. Dr. Willey Denis is teaching biochemistry in the Medical School at Tulane University.

Women have proven their ability as teachers of chemistry. Dr. Ellen Terry, assistant professor at the University of Chicago, has collaborated in the preparation of a recent textbook in general chemistry. In the two eastern women's colleges in which the chemistry department is administered by women, Dr. Marie Reimer at Barnard, Dr. Emma Carr at Mt. Holyoke, the work of the department ranks exceptionally high as is evidenced by the quality of the training and the interest of the students. Ten Mt. Holyoke graduates and five from Barnard have taken the doctorate in chemistry. At Mills College, where Dr. Vernette Gibbons is head of the chemistry department, excellent standards prevail.

In industry women have shown their capability for accurate, reliable analytical work and in a few notable instances have contributed to industrial development and research. Dr. Mary Pennington is a recognized expert in refrigeration, Dr. Jessie Minor in paper manufacture; Dr. Dora Neun is assistant superintendent in the manufacture of chemical products. Dr. Dorothy Hahn has contributed to research in dye manufacture while pursuing her work as associate professor at Mt. Holyoke College. Dr. Ruth O'Brien at Iowa State College is a recognized textile chemist whose improvements on textile machinery have been patented. During the war Dr. Mary Rising worked out with Dr. Stieglitz at the University of Chicago a method for producing luminal, a drug which had been imported, and whose lack caused a great deal of suffering. She attempted to make it according to the

process described in the patent and found that only minute quantities could be procured in that way, as was the usual result, since patents are so written as to give a minimum of evidence. The process was improved to such a point that it was taken over, with some minor modifications, for large scale work in the manufacture of the product. Dr. Stieglitz has stated that "Miss Rising's share in this work was essentially in the laboratory in which she worked very efficiently and very skillfully. There is no doubt that the keenness of her observation and closer study of laboratory details were a very vital element in the development of the method."

In short, the present is a good time for those women who will consider chemistry *seriously* as a career although tradition and prejudice against them are still to be reckoned with, especially in industry. The ability of women has been demonstrated. The air has been cleared in the period of economic depression; it is ability which will count in the future as better efficiency in industry is demanded. The period of preparation for a sound understanding of the science is necessarily a long one and only a true interest in the work itself carries the real chemist through to achievement.

PART II.

ANALYSIS OF POSITIONS IN CHEMISTRY

In general, to the student who looks forward to chemistry as a life pursuit, the field presents two main lines of work. She may be engaged in teaching or in teaching and research in an educational institution; or she may work in some specialized branch of chemistry as applied in medicine, in the public service, or in industry. These lines are by no means mutually exclusive; the chemistry applied in medicine is physiological or biochemistry in which the most important research is being conducted in educational institutions. It is applied also in certain government laboratories and in certain industries. Government laboratories require chemists with specialization in a large variety of fields, and this is even more true of industrial laboratories. Experience in teaching has been good preparation, in various instances, for work in control and research laboratories; and the reverse is perhaps even more true, that experience in a laboratory of applied chemistry has been invaluable for the prospective teacher.

Biochemistry has been recognized as a special field of work. Other special terms are used, such as food chemistry, textile chemistry, agricultural chemistry, electro-chemistry, which are less well defined and which do not really represent special fields of the science. A "food chemist" may be an analyst of food products in an industrial plant, or a specialist in nutrition in a medical laboratory or in a school of home economics—in reality a biochemist or a specialist in nutrition. Textile chemistry is a cross-section of the chemistry of dyes, bleaches, finishes, etc., plus the scientific knowledge of fibers. Agricultural chemistry is rather chemistry as applied in the problems of agriculture—the chemistry of the soil, of plants, of animal nutrition, etc. Electro-chemistry is broadly used to cover both electrolytic processes and processes to which the electric furnace is essential. Fundamental preparation in general chemistry is requisite in all.

In the following sections the analysis of positions in chemistry is based upon the kinds of work done and the kinds of institutions and organizations in which chemists are employed, rather than upon these general and partially defined classifications. Wherever

possible, the special line of chemistry applied in each field will be indicated.

The discussion will also cover the status of women in the positions analyzed, the training requisite for professional work in chemistry and such general considerations as are of importance in planning a career.

In Educational Institutions

It is the schools which give chemists their start. The most important work in chemistry therefore is the training of students. There can be no great chemists without great teachers of chemistry—teachers who are themselves inspired by a broad viewpoint for the past and the future of their science and who keep so fresh their own relation to their subject as a living science that they impart inspiration, teachers who are not only chemists but educators as well with an adequate comprehension of the educational as well as the scientific aspects of their work. This involves preparation in the philosophy of education and a practical knowledge of psychology. But the most important qualification for teaching is a *really thorough* knowledge of the subject to be taught.

Methods of teaching chemistry, objectives sought with various groups of students, contents of curricula are still open subjects for which satisfactory standards have by no means been reached. The training of the high school student is in too large a proportion of cases found to be inadequate preparation for college work; industry finds the college graduate insufficiently or improperly trained. Teachers of chemistry themselves describe the work of their profession as suffering in general from a lack of fundamental thoroughness, as not building intellectual self-reliance and stimulating the spirit of research, not emphasizing enough the importance of related sciences, not impressing students with the importance of chemistry in American life. A stirring challenge, therefore, lies before the future teachers of chemistry to contribute to the productive development of their profession.

KINDS OF WORK

Positions in chemistry in educational institutions most frequently involve three kinds of work: teaching, by lecture or quiz or both, supervision of the laboratory work of students, and research. The proportion of time given to each varies with almost

every single position, while many positions involve only one or two of these functions. The following analysis covers the usual kinds of positions in chemistry departments of educational institutions.

TEACHER

The character of the chemistry teacher's work varies almost indefinitely. She may, for example, be "lecturer, director of laboratory work and in charge of graduate research"; she may "teach general chemistry, laboratory and quiz and one class in qualitative analysis"; she may be responsible for two years of chemistry preparatory for a medical course; she may give courses in advanced quantitative and qualitative analysis to three sections, two lectures and five hours of laboratory each; she may have charge of the laboratory for the classes in general chemistry and of lectures, recitations and laboratory in organic chemistry; she may have full charge of the instruction in food chemistry; she may teach four sections five periods a week each in general chemistry; she may teach physics or biology or mathematics in addition to chemistry; or she may be in charge of all science and herself teach inorganic, organic and food chemistry, physics and bacteriology, or almost any other combinations.

In colleges and universities the teaching positions are ranked as follows: professor, associate professor, assistant professor, instructor. In a few colleges the rank of assistant professor is above that of associate professor. In some institutions a grade entitled "associate" is introduced after assistant professor. In others there is a rank below instructor, that of tutor. Some college staffs also include lecturers, whose professional status varies.

DIRECTOR OF THE DEPARTMENT

The director or head or chairman of the department of chemistry is the executive officer who organizes and supervises the work of the department; recommends what subjects shall be taught, what assistants shall be employed, how the laboratory shall be managed and what its equipment shall be; conducts some of the courses given; supervises in a general way any research carried on by colleagues or students; and is in general responsible for the policies of the department. It is especially important for the director to have an adequate comprehension of the educational significance of the work of the department.

In the university and the standard college the director of the

department has more freedom and more responsibility than in the weaker college where the limitations are greater or in the high school where the courses are more elementary and prescribed.

Women have to date attained the position of director of the department of chemistry in a limited number of women's colleges, in some smaller co-educational colleges, in schools and departments of home economics, and in a larger number of high schools. It should be noted that in departments of home economics have been found the best opportunities for advancement for women chemists.

Supervisor of Laboratory

The director of the department of chemistry has the responsibility for and general supervision of the laboratory; this responsibility may be delegated to some other member of the teaching staff. Under this responsible person, there is frequently a laboratory supervisor, whose title may also be demonstrator or curator or assistant. She is general manager of the laboratory stock, prepares lecture experiments, and is in charge of the laboratory work of the students of at least some of the classes of the department.

A curator of a chemistry department, for example, outlines her work as follows: "I keep all laboratories in running order so that instructors have only teaching to do. This is done mainly by student help which I have to oversee. I have charge of all supplies and do the ordering and checking up of supplies. I am secretary to the head of the department, typewrite and mimeograph all laboratory directions, make up and standardize solutions. In fact I must be able to do anything anyone wants done!"

In a state university a woman with the rank of instructor has entire charge of the laboratory in one of the freshman chemistry courses with eleven assistants teaching laboratory under her. She also conducts the recitations of two sections of the class.

Assistant

The assistant is at hand to supervise and help in the laboratory work of students. She may be in charge of the laboratory work of all beginning students, or of a variety of undergraduate courses, and may be called laboratory instructor. She may do some teaching; in one instance, for example, an assistant in charge of three laboratory sections of one hundred students each (with two helpers) teaches three quiz classes each week.

She may spend only a part of her time in laboratory supervision, the remainder in helping in research work. In one case, for example, one-fourth time was spent in the laboratory with the students taking the first course in chemistry, three-fourths in working out processes of organic synthesis to produce certain organic chemicals. This included the investigation of processes previously used as well as experimentation with new methods of production.

In technical or professional schools the assistant may do clinical analysis, agricultural experimentation, biological research, etc. It is evident that the assistant is in a position where she may gain much valuable experience and training—an apprenticeship position. In some instances the assistant is a graduate student dividing her time between research and laboratory supervision.

RESEARCH WORKER

There are a number of excellent opportunities to secure employment as research assistant in university departments of chemistry. In some universities specific grants are made for the support of research work. Industries, trade associations and private individuals have in various instances provided funds for research on special problems to be carried out in university laboratories. Provision is made in several medical schools for extensive research in biological chemistry and in pharmacology. It is perhaps in these schools that women have found the largest number of opportunities to secure paid research work, although women have also been employed for research in other fields than that of physiological chemistry.

The salary of the research worker is usually small but there is large compensation in the unusual opportunity for continuing study without economic strain. The research work in most instances is accredited as graduate work and may readily lead to a thesis acceptable for the doctorate in chemistry.

There are also many fellowships[1] for graduate study in chemistry which offer similar opportunity for subsidized research work. Not all are open to women and there has been some discrimination against women in the granting of unrestricted fellowships. A number of universities, however, have been notably free from such discrimination and in many instances women have completed their graduate training with the aid of fellowships in chemistry.

One graduate student who devotes most of her time to research

[1] For a list of such fellowships see appendix.

work under supervision describes her work as that of "research chemist in by-product recovery—the only position of the kind in the university. So far, I have been doing industrial research in this university, on lubricating oil and gasoline problems, some of which were in the nature of consulting problems from firms and some patentable processes connected with their refining and use."

A research assistant in the public health department of a medical school describes her duties as follows: "My work is based on principles of physical chemistry, but I employ bacteriological methods and bacteria as material. My employer is interested in the problem of the mechanism of disinfection. Under his direction I carry on research on this subject. We use bacterium coli as a test organism and record its viability while subjected to the solution under observation—for example, the mineral salts potassium and magnesium chlorides. This is done by plating definite quantities of the organisms taken from the solution in which they have been suspended, in a nutrient medium, agar. The number present at the time of plating can be counted on the plates after twenty-four hours of incubation. We thus get a quantitative record of the effect of a given solution. The work is more closely allied to physical chemistry as applied in *general physiology* than to pure physical chemistry."

In some instances research is a definite part of the teacher's assignment; usually it depends upon her own initiative and is carried in addition to a full schedule. In the former case, a course in research may be offered in which teacher and advanced students work on special problems together; or the teaching schedule may be shortened in order to give time for research in problems which may be designated—nutrition, practical industrial matters, etc.—or which may be left to the teacher's inclination.

"It is a matter of common knowledge that the most serious limitation of the research productivity of these institutions is occasioned by the overwhelming burden of classroom instruction which many of the men are obliged to carry. Such classroom work is not only destructive to research because of the sheer intellectual and physical fatigue which it occasions, but also, and perhaps more significantly, because of the interruption to attention and the close observation of critical phenomena which it compels. In some fortunate institutions provision has been made for considerable periods of uninterrupted research work, and again, in certain other institutions men can so arrange their teaching duties as to secure freedom in certain portions of each week. But, in

general, university research is carried on in the interstices of other duties, and the only wonder is that so much of it is produced, and that on the whole it is of so respectable a character."[1]

KINDS OF SCHOOLS

SECONDARY SCHOOLS[2]

Chemistry is first taught in the high school or special school of high school grade. The contents of the high school courses in chemistry have been largely dictated by the entrance requirements of colleges and technical schools, and include primarily one year of general inorganic chemistry. Since only the larger high schools enroll a sufficient number of pupils to justify the employment of special chemistry teachers, the majority of teachers of chemistry in high schools combine with chemistry at least one other subject, the selection of which is apt to be based first upon the exigencies of the school and second upon the ability and preparation of the teacher. One important university advises *men* who are looking forward to teaching chemistry in secondary schools to be prepared also to teach physics, mathematics or geology; while *women* are advised that it is wiser to combine chemistry with home economics, physics, physiography, physiology, botany or zoology.

In the larger high schools there are employed for the teaching of chemistry an executive head of the department, teachers, and assistants. In the smaller high schools, the whole work devolves upon the same person with, frequently, additional subjects to teach.

The mailing list of the United States Bureau of Education[3] has contained the names of 16,300 high schools in the United States. It is safe to assume that the great majority of these offer some training in chemistry. This would very probably be true of the 10,638 four-year high schools and certainly of the 6,866 accredited high schools. The 1,385 city high schools, enrolling over 52 per cent of the total number of high school students with an average enrollment of 653 students each, probably all employ at least one teacher for chemistry only. Although 66 per cent of all high school teachers are women, it is probable, since men are preferred as science teachers, that not more than 50 per cent of high school chemistry teachers are women.

In many instances women hold important positions as teachers

[1] James Rowland Angell, The Development of Research in the U. S., Bulletin Number 6 of The National Research Council.

[2] See Reorganization of Science in Secondary Schools, U. S. Bureau of Education Bulletin, 1920, No. 26.

[3] Statistics of Public High Schools, U. S. Bureau of Education Bulletin, 1920, No. 19.

and as heads of chemistry departments in large high schools. In too many cases high school teachers of chemistry have had only undergraduate training and can scarcely be rated as chemists. On the other hand they frequently lack any professional training in education.

The conclusion is that the high schools afford a fertile field of opportunity for the woman who is keenly enough interested in education to choose it as her calling and who prefers science as the subject she will prepare to teach. The secondary school offers the greatest opportunity for awakening and nurturing a love of science; for there is the opportunity of reaching a larger proportion of young people of school age than will be found in any higher institution; it is also true that the pupil's first acquaintance with a subject has the largest influence upon his life relation to it.

COLLEGES AND UNIVERSITIES

In college and university teaching the instruction of students is the most important duty as it is in secondary schools; college and university teaching, however, demands a more complete mastery of the subject taught and implies continued research. The college and university teacher must be prepared to teach all fundamental branches of chemistry. Where the department is large enough the work may be divided into inorganic and physical chemistry and organic chemistry, with sometimes a special division for physiological or biochemistry. The teacher who has become expert in a special subject usually has the opportunity to conduct courses in the field of her own research.

Just what proportion of time and energy the college teacher should give to research is a moot question. It has been estimated that the average faculty member of a certain university spends 20 per cent of his time in miscellaneous activities, such as administration, professional reading, addresses, editorial work, etc., 10 per cent in personal research, and 70 per cent in regular instruction work.[1] Research depends upon the ability, interest and devotion of the teacher; too seldom is provision made for it in the schedule. It depends also in considerable degree upon the attitude of the head of the department towards the development of opportunities for research. The research work of the teachers gives inspiration and stimulus to the whole program of the department.

The United States Bureau of Education lists 608 universities

[1] Walter Dill Scott, Occupational Description of our Faculty Positions—School and Society, October 15, 1921.

and colleges.[1] The catalogues of a selected 177 of these bear the names of 213 women teachers of chemistry. Of this number 22 or 10.32 per cent are of full professorial rank, while 35, or 16.43 per cent, are associate or assistant professors, 156 are instructors and assistants (exclusive of student assistants). Of the men teachers of chemistry in these same institutions, 27.59 per cent are professors and 24.19 per cent associate and assistant professors. The lower rank of women teachers is emphasized by the fact that the 22 full professors are located, 18 in women's colleges (with two striking exceptions, the smaller women's colleges) and 4 in small coeducational colleges. Of 6 leading women's colleges only two have women as full professors; one of the two has three such professors. The remaining four have a man as head of the department and women associate and assistant professors. Twelve of the 14 associate professors and 13 of the 21 assistant professors are located in women's colleges; 5 are in university departments of chemistry, the remainder in co-educational colleges. Women instructors and assistants are found in every type of college and university.

The distribution of chemistry teachers in these 177 institutions is as follows:

Distribution of Chemistry Teachers in 177 Colleges and Universities

		Professors	Associate Professors	Assistant Professors	Instructors	Assistants
All teachers	1242	306	109	175	305	347
Men	1029	284	95	154	214	282
Women ...	213	22	14	21	91	65
Percentage of Women	17.14	7.18	12.84	12	29.83	18.73

For advancement in college and university teaching not less than the degree of doctor of philosophy is considered adequate preparation. In the smaller colleges the preparation demanded for the master's degree is often considered sufficient, but an academic career of real promise demands as never before research ability and training. With the bachelor's degree, there is frequently a good opportunity to gain experience as an assistant or an instructor before or during the period of graduate work.

The preparation of women chemistry teachers for their profession as evidenced by academic degrees held would seem to indicate that rank has, in general, been commensurate with training; without the first graduate degree advanced rank is seldom

[1] Educational Directory, U. S. Bureau of Education Bulletin, 1922, No. 48.

attained in any college and the doctorate is essential for recognition in the larger colleges and universities. The degrees of women teachers of chemistry in 177 institutions are as follows:

Degrees of Women Chemistry Teachers in 177 Colleges and Universities

	Ph.D.	M.D.	Sc.D.	M.A.	M.S.	A.B.	B.S.	Ph.G.	None	Total
Professors	8		1	5	2	2	4			22
Associate professors	5			4		4	1			14
Assistant professors	6			7	3	4	1			21
Instructor	6	1		17	8	30	25		4	91
Assistant	1			1	6	34	16	1	6	65
Total	26	1	1	34	19	74	47	1	10	213

Colleges. Colleges of arts and sciences in most cases aim primarily to give the fundamental courses in chemistry, inorganic, organic, analytical and physical, which lay the foundation for graduate work. In some colleges the advantage of students who will not pursue chemistry has been favored by the introduction of more popular informational courses in the relation of chemistry to everyday life, or of practical courses, in food chemistry or sanitary chemistry, for example. In other colleges courses of immediate vocational value, soil science, gas analysis, photography, etc., have been introduced. In some instances the specialties of the professors in the department appear in the curriculum—colloids, metallurgy, etc.

The size of the department and the degree of specialization in the college teacher's assignment depend upon the enrollment and endowment. A full professor, who is the head of the department, two associate and one assistant professors or one associate and two assistant professors, and one to six instructors and assistants represent approximately the usual staff of the chemistry department of a college with a thousand students.

Universities. The work in a university differs from that in a college chiefly because of the presence of graduate and professional departments, which mean a greater variety of courses to be given, more adequate equipment, more research work, larger opportunity for association with fellow scientists, greater stimulus for the teacher. The college teacher devotes herself to the instruction of the undergraduate; the university teacher may give her whole time to this object but is likely to be connected also with the specialized and graduate work. The college usually affords opportunity for more individualized teaching; the college teacher pursues

her study and research from interest in her subject, but chiefly, as Dr. Arnold expressed it, that the students may "drink from a running stream rather than from a stagnant pool." In the university the individual undergraduate is apt to be less important, and the emphasis to center rather in the advanced work and the pushing forward of the science itself.

VOCATIONAL AND PROFESSIONAL SCHOOLS

Schools of Home Economics. The chemistry taught in schools of home economics is chiefly food chemistry—nutrition, chemistry of the leading tissues, with such related matters as the chemical changes in food in cooking, food industries, water analysis, the effect of cooking utensils on food products, and the like. Thorough fundamental training in chemistry is necessary preparation for this teaching, with supplementary training in the related sciences. Textile chemistry is frequently also included in the curricula of these schools.

The work of individual teachers in schools and departments of home economics also varies extensively, as may be seen from the following instances of women trained in chemistry.

An instructor in the household science department of a university gives a course in food and dietetics for nurses, three lecture hours and six hours of laboratory, and a course in food economics, two lecture hours and six hours of laboratory; half of her time is assigned to research.

An associate professor in the department of household arts in a vocational school lectures and conducts the laboratory work in physiological chemistry and teaches dietetics and nutrition.

An associate professor of household science in a university lectures and supervises the laboratory work in dietetics, administers details of the department, directs research and does some writing.

The chairman of the department of home economics in a state university coordinates all the work of the department, teaches four to six hours a week, directs research, advises with students and does extension work.

An associate professor in a large university classifies her duties into three groups: 1. "I teach food chemistry and nutrition, giving lectures and supervising laboratory work. 2. I direct research work of students, candidates for master's and doctor's degrees. 3. I am chairman of the home economics department, with the diversified administrative work involved in that." Her conviction is that "the woman biochemist with interest in nutrition of human beings, especially children, has many opportunities in college and

university home economics departments. In only a few cases can she teach biochemistry only; usually she also gives work in dietaries, occasionally in other subjects involving less chemistry."

Chemistry teachers in departments of home economics are carrying on important research in nutrition; in a number of instances they teach graduate as well as undergraduate students and direct the research work of graduate students.

The majority of schools of home economics are departments of colleges and universities in which other academic and vocational courses are also offered. Such departments are evidently primarily of interest to women and in them women teachers meet less competition on the basis of sex than in any other kinds of schools. There is a growing appreciation of the fundamental importance of chemistry in the home economics curriculum. For all these reasons women trained in physiological chemistry, with preferably some special knowledge of food *preparation* as well, are finding excellent opportunities for satisfactory work, advancement and salary in schools of home economics.

In a number of instances women with thorough training in chemistry have been chosen as deans or chairmen of large departments of home economics or household science; for example, Dr. Katherine Blunt at the University of Chicago, Dr. Helen Bishop Thompson at Kansas State Agricultural College, Mary E. Sweeney at Michigan Agricultural College, Dr. Agnes Fay Morgan at the University of California.

The United States Bureau of Education has listed 365 colleges and universities in which home economics is taught, with a total of 1149 teachers; 180 of these schools and departments have only one instructor in home economics, while about 100 have but 2 or 3; in 65 there are from 4 to 10 teachers, in 6 from 11 to 20, and in 11 from 21 to 54.

Schools of Agriculture. The chemistry department of schools of agriculture is concerned with the study of the composition and chemical properties of soils, fertilizers, foodstuffs, insecticides and fungicides, the chemistry of dairy products and plant products, and with problems of animal nutrition. Such schools are often grouped with one or more academic or vocational departments, usually at least a department of home economics, or form one unit in a university. Frequently an agricultural experiment station is attached to the school, in which case there is increased opportunity and equipment for research.

A professor of chemistry in a college of agriculture points out

that there is a good deal of hard manual work connected with either animal nutrition or field crops, which it would be necessary for a beginner in agricultural chemistry to do and which women would find difficult; but that laboratory work, in feed and fertilizer control, for example, would be entirely suitable for women. Men predominate as teachers of chemistry in schools of agriculture. There are, however, women who are successful in such positions, and there are no reasons why they cannot give adequate instruction in the chemistry of agriculture or why they should not be fundamentally interested in the subject matter, as the following examples illustrate.

One instructor in a state college of agriculture came to her position with experience in the water laboratory of a state board of health and in an industrial laboratory; her entire time is devoted to teaching.

An assistant professor in an agricultural college teaches only junior and senior students in flour mill engineering; a part of her time is devoted to chemical analysis of wheat and flour, milling tests of wheat and baking tests of flour in the experiment station.

A third example is that of a woman who does only emergency teaching; her work she describes as "keeping track of the literature that comes out in our line, abstracting or translating parts and making a card index, also editorial work for the division, some writing of articles and collecting material on specific subjects as there is occasion. Besides, I have the last two years gone into the laboratory some to help in the chemical analyses and animal feeding tests. The research work is fully directed and the individual is independent only as to details. In the department not more than two or three, at the most, can claim to be independent. However, there is much opportunity for the individual to show initiative if she has it and to make herself felt in plans."

An instructor in the agricultural college of a state university finds instruction the least of her assignments, and primarily does research and analytical work in the associated agricultural experiment station.

The latest report of the United States Bureau of Education includes 51 schools of agriculture.

Schools of Engineering. General chemistry is a universal requirement in schools of engineering with fundamental and specialized work in inorganic, organic and physical chemistry as related to industry—methods of electrochemical analysis, water, gas and fuel analysis, oil testing, chemistry of dyes, rubber, engineering

materials, and so on. For ceramic engineering, chemical engineering, metallurgical engineering, mine engineering, special work in chemistry forms an important element in the training. Teaching in engineering schools is as yet almost exclusively done by men teachers. There are listed by the United States Bureau of Education 130 colleges or schools of engineering.

Schools of Medicine. Schools of medicine receive students on the assumption that they are already thoroughly grounded in the principles of chemistry, and themselves aim to impart such a fundamental knowledge of organic and physiological chemistry as is necessary for the comprehension of the bearings of chemistry upon physiology, pharmacology and medicine.

Very few women are as yet teaching chemistry in the 85 medical schools of the country, and those few are chiefly instructors and assistants. There are, however, notable exceptions; in the medical school of a state university a woman with a doctor's degree in chemistry from the University of Prague has been assistant professor of medical chemistry and carries on research on the spinal fluid. In another university a woman chemist as assistant professor is responsible for the teaching of physiological chemistry in the medical school. Dr. Martha Tracy is dean and professor of physiological chemistry in the Women's Medical College of Pennsylvania. A number of women research workers are associated in various medical schools with professors of physiological chemistry and of pharmacology who are engaged in important investigations.

Schools of Public Health.[1] Attached to medical schools or universities or, in rare instances, as independent institutions, there is a small but increasing number of schools of public health in which are given courses in physiological chemistry—analysis of water, sewage and air, drugs, the detection of adulterants, food chemistry, nutrition, methods used for the study of metabolism, and related matters.

The head of the biochemistry department in one such school is conducting extensive research into the whole problem of the nutritive value of foods and diseases resulting from various forms of malnutrition. A woman instructor is associated with him in attempting to isolate one of the so-called vitamines found in natural foods.

In the schools of public health at Harvard University, Johns

[1] For a list of Graduate Schools of Public Health, see The Journal of the American Medical Association, August 13, 1921, p. 538.

Hopkins University and elsewhere, women chemists have been employed for research and as instructors in physiological chemistry.

Schools of Dentistry. Schools of dentistry require instruction in practical dental metallurgy, including a study of the various metallic elements used in dentistry, with such physiological chemistry as gives the elements of normal nutrition.

"As dentistry is more and more coming to be considered a specialty of medicine it becomes necessary to broaden the chemical field covered by the dental curriculum to include not only the metallurgy and qualitative analysis, which a few years ago constituted nearly the whole of dental chemistry, but also practically all the branches required by the medical schools, with emphasis directed of course to dental rather than medical requirements."[1]

The opportunity for teaching chemistry in schools of dentistry is limited because only 47 such schools are recognized and of these not all have reached the advanced conception of the place of chemistry in the curriculum which is described above.

Schools of Nursing. The chemistry taught in schools of nursing is largely preparatory to a better understanding of the chemistry involved in other subjects of the curriculum—"a study of the elements and their common chemical combinations, especially related to food and cooking processes, to cleansing processes, disinfection and materia medica; physical principles underlying nursing procedures, conservation and transformation of energy, ventilation, heating, reduction of temperature, gas and electric apparatus, etc." Since chemistry forms only a small part of the instruction it can be taught by a professor from the related medical school, or by a teacher in the nurses' training school who combines other subjects with it, frequently anatomy and physiology, or by a part-time teacher who may be paid by the hour.

Schools of Pharmacy. In schools of pharmacy, general and analytical chemistry are taught from the standpoint of the pharmaceutical chemist, and therefore involve the consideration of all the official and important pharmaceutical chemical preparations and compounds derived from them, with such biological chemistry as will equip the analyst to consider and act upon the natural changes which substances undergo when absorbed into the living body. Approximately two years of work are offered in each of the 66 schools of pharmacy listed by the United States Bureau of Education. Dr. Nellie Wakeman, with a degree in chemistry, is teaching in the Department of Pharmacy at the University of Wisconsin.

[1] Harvard University, Announcement of The Dental School, 1919-1920.

Schools of Education. Although the science courses in schools of education are usually courses in the methods of teaching science, some normal schools offer fundamental courses in the science itself. A woman in a state normal school, for example, is in charge of the science department and herself teaches inorganic, organic, food and physiological chemistry with urinalysis and bacteriology.

The reports of the United States Bureau of Education include 336 public normal schools and 55 private normal schools.

In Laboratories for Medical and Related Analysis and Research

The work in these laboratories falls entirely within the field of physiological chemistry or biochemistry. Biochemistry is a branch of organic chemistry which includes the chemistry of the cells and tissues of plants and animals, the principles of nutrition, the chemistry of the internal secretions, the chemical correlation of the organs of the body, the chemistry of the digestive processes and of the secretions and excretions; the chemical basis of such problems as those of pigmentation, inheritance, fertilization, irritability, and so on. It has to do also with the derangement of chemical processes in disease. The science thus stands in a close and complementary relation with zoology, botany, anatomy, pathology, physiology, and bacteriology on the one hand, and with chemistry on the other.

Scientific medicine today acknowledges the fundamental value of chemistry in the fight for the prevention and cure of disease; the physician is turning to the biochemist for a clarification of the problems as to how the organism carries on its activities. The specific service that constructive chemistry can render to medicine in the prevention and cure of disease has been summarized as follows in the report of a committee of the American Chemical Society:[1]

1. The preparation of the specific medicament for the cure or alleviation of the specific disease.

2. The isolation, study, and, if need be, the artificial preparation of pure organic principles of fundamental importance to our life, such as principles of secretion of the body organs, of which a deficiency or an excess would cause disease.

[1] The Future Independence and Progress of American Medicine in The Age of Chemistry, the Chemical Foundation, New York, 1922.

3. The complete ultimate analysis of the constituents of our body cells, of the components of the blood, of tissues, together with the complete ultimate analysis of the components of our foods—so that we may have complete knowledge of the body in health and of what it needs to preserve its health.

Research work in physiological chemistry is conducted in universities—particularly in the medical schools,[1] also in schools of home economics[2] and schools of agriculture;[3] in Government laboratories;[4] in industrial establishments;[5] in laboratories of hospitals and in special institutes for medical research.

Reports of research have been contributed to the Journal of Biological Chemistry during the years 1920 and 1921 from the following laboratories:

Schools of Medicine

University of California
Cornell University
Harvard University
University of Illinois
University of Iowa
Johns Hopkins University
University of Minnesota
New York Postgraduate Medical School and Hospital
University of Pennsylvania
College of Physicians and Surgeons, Columbia University
University of Pittsburgh
Rush Medical College, University of Chicago
Leland Stanford Junior University
Washington University, School of Medicine
University of West Virginia

University Departments

University of California, Laboratories of Biochemistry
University of Chicago, Department of Physiological Chemistry and Pharmacology
University of Cincinnati, Biochemical Laboratory
Columbia University, Department of Chemistry
Teachers College, Department of Nutrition
Harvard University, Department of Chemistry

[1] See p. 19.
[2] See p. 17.
[3] See p. 17.
[4] See p. 155 ff.
[5] The National Research Council has listed 46 industrial establishments in which research work in biological chemistry is being conducted. See also p. 85.

University of Illinois, Department of Physiological Chemistry
Iowa State College, Department of Chemistry
University of Iowa, Child Welfare Research Station
Department of Nutrition
Johns Hopkins University, Department of Chemical Hygiene
Leland Stanford Junior University, Department of Chemistry
University of Minnesota, Division of Agricultural Biochemistry
Division of Home Economics
University of Oregon, Department of Chemistry
University of Rochester, Department of Physiology
Vassar College, Physiology Laboratories
Williams College, Physiology Laboratories
University of Wisconsin, Department of Physiological Chemistry
Department of Agricultural Chemistry
Yale University, Sheffield Laboratories of Physiological Chemistry

Industries

Armour and Company, Research Laboratories in Organotherapeutics, Chicago
Digestive Ferments Company, Department of Bacteriology, Detroit
Fleischmann Company, Biochemical Laboratory, Chicago
Kober Chemical Company in cooperation with the Klett Manufacturing Company, New York
Parke, Davis & Co., Biological Research Laboratories, Detroit

Government Laboratories

Department of the Treasury, Public Health Service
Division of Pharmacology
Hygienic Laboratory
Department of Commerce, Bureau of Standards
Department of Agriculture
Bureau of Animal Industry
Bureau of Chemistry
Bureau of Plant Industry
States Relations Service, Office of Home Economics
Agricultural Experiment Stations
Baton Rouge, Louisiana
Geneva, New York

Lexington, Kentucky
New Haven, Connecticut
Stillwater, Oklahoma
Wooster, Ohio
Fargo, North Dakota
Columbia, Missouri

Hospitals

Bellevue and Allied Hospitals, New York
Lankenau Hospital, Philadelphia
Massachusetts General Hospital, Boston
Memorial Hospital, Huntington Fund for Cancer Research, New York
New York Hospital, New York
Pennsylvania Hospital, Philadelphia
Roosevelt Hospital, Harriman Research Laboratory, New York
Russell Sage Institute of Pathology, Bellevue Hospital, New York
St. Luke's Hospital, Chicago
Walter Reed General Hospital, Washington

Institutes for Research and Private Laboratories

Carnegie Institution of Washington
  Nutrition Laboratory
  Marine Laboratory
Dermatological Research Laboratories, Philadelphia
Henry Phipps Institute, Philadelphia
Dr. James P. McKelvey, Pittsburgh
Mayo Foundation, Section on Biochemistry, Rochester, Minn.
H. A. Metz, New York
Rockefeller Institute for Medical Research, New York

The large bulk of the work in this field is, however, not research, but the analytical work of hospital and private laboratories. Not all hospital laboratories offer work that is purely chemical. The routine laboratory work is chiefly of a bacteriological or histological nature and the chemical tests that have been employed require but a small amount of chemical training. It is only recently, however, that blood chemistry has assumed such proportions; with the increasing importance attached to chemical tests in the medical field there is a growing demand for physiological chemists in hospitals and in private laboratories of physicians. In the larger hospitals the laboratories frequently have a separate chemical section.

Work in hospital laboratories is vocationally closely related to medical work and yields similar satisfaction to the trained scientist. The greatest difference is that the work does not involve the same direct human contacts. A chemist in a hospital laboratory, for example, wished to study medicine but did not feel that she had the make-up of a general practitioner; she therefore chose chemistry "as the next best thing."

Work in these laboratories, on the other hand, often stimulates an interest in medicine and provides an incentive for taking a medical course. Students who look forward to a medical course have also found the experience in a hospital laboratory excellent preliminary preparation.

There is concurrence in the approval of women's exactness and carefulness in chemical work in this field. The statement of a physician of long experience emphasized these qualities:

"It has always seemed to me that chemistry opened a particularly good field for women. They are by nature more painstaking and exact than men and their physical limitations do not militate against work of a high order in this field. In my long experience in the field of biochemistry and clinical medicine, I have been struck by the aptitude which young women display in entering into a chemical career. There are many problems of extreme importance in clinical medicine which are also very attractive to the research worker in chemistry, because such problems are only capable of chemical solution and nearly all of them have a direct relationship in furthering knowledge of chemical physiology and sometimes the therapeutic treatment of disease, and surely this is a noble aim for the research worker."

The following comments of the director of a laboratory in this group again bear evidence of the carefulness of women's work, but suggest also some limitations to be overcome:

"I think that probably the greatest difficulty with women's work in chemistry, in fact the average college graduate's failure, can be ascribed to inability to adjust themselves to new environment. Women are most painstaking, I find, follow directions admirably, much better than men, and as routinists are preferable. They are not original, or at least very rarely so, and have not the ambition that men have. It is very difficult to get women assistants, for example, to do anything in the line of advancement outside of laboratory hours, whether it be in the direction of general culture or special work."

KINDS OF WORK

TECHNICIAN OR ASSISTANT

The term technician is commonly used in the hospital laboratory to designate the assistant or analytical chemist. *Assistant* is coming to be the preferred term for a trained person, technician is regarded as defining a position from which there is no advancement, whose duties are routine and readily performed by a slightly trained person. Trained workers are increasingly desired as assistants, and the experience in a well-conducted hospital laboratory is considered a valuable one as preparation for further work in the field of physiological chemistry—better experience than that gained in the private laboratory of an individual physician.

In certain hospitals it is the custom to assign the laboratory testing to physicians in training, thus correlating their training in chemistry with the work in the various departments of medicine and surgery. From the records obtained in the laboratory the student makes a provisional diagnosis which is criticized and corrected by the physician in charge of the case.

The work of an assistant is described by various women holding such positions in hospital laboratories. Several brief descriptions follow:

"Analysis of blood and urine for quantitative determination of sugar, total nitrogen, urea, etc. Qualitative analysis for poisons. I also do the urine analysis at the dispensary connected with the hospital. I have a chance to learn all sides of the laboratory work, bacteriology, etc."

"Quantitative analysis of blood for non-protein nitrogen, urea, uric acid, and sugar. Routine and microscopic work on urine. Quantitative analysis of urine for sugar and albumen, and determination of the urea and ammonia coefficients. Routine work on feces."

Chemical technicians are frequently appointed as distinct from *bacteriological* technicians. In many laboratories, however, the routine work of these two converges in one position, as is true in the following instances:

"My work is not entirely chemical. It comprises bacteriology and the ordinary chemical analyses of urine, stomach contents, etc."

"Technicians' work included urinalysis, both chemical and microscopical examination; blood counting, bacteriology, including the making of vaccines and sera, Wasserman reaction, and examination of spinal fluids. This was all routine work; a hospital

chemist was employed who did all special and complicated chemical tests of any kind, including the blood chemistry."

For many who have really cared for their work the position of technician, though it has its routine aspects, holds great interest and satisfaction. After three years a woman testifies that she attacks each urinalysis with a new enthusiasm. Others comment similarly:

"It never grows tiresome, for there is nothing monotonous about it."

"Of course, for those whose aim is usefulness, there can be no question about the usefulness of routine laboratory work. It is almost essential to hospital management and it is absolutely essential to any development in medical science."

The experience gained by the assistant in a hospital laboratory is valuable for one who plans to study medicine, to prepare to do research work in physiological chemistry or to become head of a hospital laboratory or pathologist. For all of these lines of advancement further training is essential. It is frequently easy for the technician to continue her study while she is working, especially if she can do so in the associated medical school. The experience in a hospital laboratory is valuable preparation also for work in board of health laboratories or private laboratories.

Technicians or assistants are employed in connection with research work conducted in hospital laboratories as well as for regular analyses. One such technician describes her work as follows:

"I am working on the technique of the urinalysis with centrifuge, total solids of urines, and am about to start on the study of galactose in biofunctional tests, especially on the non-secreting glands. The work is chiefly analytical. At present I am the only assistant, but later another girl will be there to do the routine."

Chemist

This may be as general a term as technician or assistant, involving bacteriological as well as chemical work. In a smaller hospital a chemist describes her duties as including:

"Routine work from hospital, as urine analysis, blood counts, blood culture, bacteriological smears and cultures, pathological sections of tissue, physiological chemistry—quantitative determinations of urea, blood, sugar, etc."

The title bacteriologist may be applied for exactly this same work, as may be illustrated by quoting the description of the duties of a "bacteriologist" in one hospital laboratory, whose preparation was a college course with a major in chemistry, followed by a summer's work in bacteriology:

"General routine examinations of urine, feces, sputum, blood, etc., both chemical and bacteriological. Blood work includes blood counts, etc. Also X L cultures, spinal fluid, pleural fluids, gastric contents.

"Duties also include teaching a nurse on duty in the laboratory the more common routine work as urines, etc. In addition, I have taught two courses in chemistry for nurses, both elementary chemistry."

It may be noted that a thorough foundation in chemistry is increasingly requisite for work in bacteriology.

The title of chemist is more usually applied to purely chemical work in the hospital laboratory, as in the positions with the following duties:

"Quantitative chemical examinations of blood, urine and feces. A little food analysis."

"I take care of all requests coming in for any chemical work, consisting mostly of chemical analyses of blood, urine and organs obtained at autopsy in case of suspected poisoning. In addition, I am conducting an extended investigation as to the relation of anaesthesia to acidosis and of pregnancy to acidosis—running complete blood and urine analysis of patients before and after operations and during the several stages of pregnancy."

Instances are found in which the chemist's work is primarily the important blood analysis and her title is blood analyst. Such a chemist in a private hospital for diabetes and nephritis describes her position thus:

"My work consists in the analysis of blood for urea, chlorides and sugar, acetone, CO_2. Occasionally I do some work on urine."

The hospital chemist has the same opportunity for study as has been indicated for the assistant. An example of a possible arrangement is the position of a physiological chemist who has had training and experience in X-ray work and bacteriology as well as chemistry. In her present position her duties are X-ray work, the making of Dakin solution, bacteriology and blood chemistry. She is also doing graduate work in blood chemistry with the pathologist who is at the head of the hospital laboratory.

Because of the frequent association of hospitals with medical schools positions in the laboratory may also be combined with teaching. One woman, for example, is chemist of a smaller hospital and assistant in the biochemistry department of the medical college. She describes the work of her double position:

"Routine urine, blood, stomach content and feces analysis for

the hospital. I take charge also of laboratory work and quizzes and correct papers for organic and physiological chemistry courses."

In larger hospitals, as has been noted, there is often a separate division of chemistry in the laboratory. In such cases the division is headed by a thoroughly trained physiological chemist who may be termed clinical chemist. Occasionally the title of chemist to the hospital may be an honorary one held by a professor of chemistry in the medical school; the main responsibility of the laboratory is then borne by the assistant chemist. A woman assistant chemist in such a position, who has taken a Ph.D. in chemistry and also some work in a medical school, considers essential for her responsible work either a Ph.D. with some medical training or an M.D. with laboratory training in chemistry. She supervises all tests made for diagnostic purposes, including X-ray work, bacteriological examinations, serological examinations, blood chemistry, urinalysis, and the like, but about 75 per cent of her time is taken up in research on biochemical problems.

There is always an element of research in the examination of surgical and pathological tissues. Although routine analyses can be made by skilled assistants, the results cannot be so interpreted. In order to be of maximum service in the field of hospital activities, the efficient biochemist must be well informed and able to think in terms of all branches of chemistry and must be familiarly acquainted with the principles of physics and general biology. Upon this groundwork a knowledge of physiology, bacteriology, morphology and pathology must be built for constructive work in this field.

Pathology is a highly specialized field; for work beyond clinical analysis a medical course is requisite. A woman who took first a year of graduate work in chemistry, then a medical course, has been three years in the department of pathology and bacteriology in a medical school, working chiefly in the laboratory. She writes:

"My work involves teaching, the examination of specimens removed at operation, the performance of autopsies, and the bacteriological and serological examination of specimens from the patients—sputum, blood, urine, feces, pus, etc. The position requires residence in the hospital. My present title is that of instructor in the medical school."

Clinical Pathologist

This general term is used in hospitals, especially where there are no chemists as such. The *pathologist* is a medical specialist in disease, its nature and the functional and material changes caused

by it. The *clinical pathologist,* however, is the assistant who makes the laboratory analyses required by the pathologist, a valuable aid to the pathologist.

The clinical pathologist may be the only laboratory worker in a small hospital; her duties may correspond closely to those of other workers who may be called technicians or assistants. The work may be chiefly bacteriological or partly bacteriological and partly chemical and involves also serology and histology. This appears in the description given by several clinical pathologists of their work:

"I did all the laboratory work for the dispensary. It included examination of all kinds of materials from patients—but only the simpler examinations."

"I was responsible for all the routine throat cultures (examining for diphtheria) and a good deal of the bacteriology (examination of sputum, blood, etc.). I made all the Wasserman tests and all the haemalyses tests."

"I have entire charge of laboratory doing all the work except routine urinalysis. This includes a wide range of chemical, bacteriological and microscopic examinations. Last year I made over 4,000 examinations."

PHARMACOLOGIST

Pharmacology deals with the chemistry of drugs, the detection of poisons, the nature and mode of action of chemical agents on organisms, and with the alterations of the physiological processes of the body produced by chemical agents of all kinds. It is a kind of bridge between physiology and therapeutics. It is a part of the physician's training.

A careful distinction must be made between the pharmacist[1] and pharmacologist. The former is concerned with the compounding of drugs, a strictly limited and specialized field. The pharmacologist is concerned with the action of drugs on physiological processes, and must have a good foundation in chemistry and biology. The vocational applications of this science are limited to teaching and research work, except as it forms an important part of the physician's equipment. There is also a limited field for the pharmacologist in the physiological standardization of such drugs as digitalis, ergot, etc., for pharmaceutical houses.

[1] See p. 193.

Research Chemist

The research work in a hospital laboratory may be directed by the head of the laboratory or may be directly under the jurisdiction of a member of the staff of the medical school with which the hospital is associated. Chemists may be working entirely in connection with research, as has been said, in hospital laboratories, private laboratories and institutions for medical research, as well as in university departments and in some industries and government laboratories.

It is often assumed that research and routine work are diametrically opposed. Even research has an element of routine. After the problem is determined and the plan mapped out, it may mean many weeks of "routine" work to get the desired results. Patience is very necessary.

The work of several women who are research chemists in hospital laboratories may be cited to illustrate the variety of concrete problems which are studied.

A woman who has been three years in such a position describes her work as all research in connection with nutritional diseases of infants.

In a hospital devoted to cancer a woman chemist's work is "research, almost exclusively along physiological lines. There are different problems at different times such as the chemical composition of blood in cancer, the effect of intravenous injection of active deposit of radium on metabolism—some work on method."

A woman working under a research chemist in another hospital is called assistant biochemist. Her work is principally with research on urine, feces and special results of metabolism.

A doctor associated with a hospital was entrusted with a fund for a special piece of research work; he is studying the effect of diet on certain patients—the degree of putrefaction in certain diseases, notably nephritis and diabetes, other disorders of the digestive processes and the reaction to certain diets. A woman as his assistant carries out the laboratory part of this research. As associate in biochemistry, Mathilde Koch has reported the results of work on research problems at the School of Hygiene and Public Health of Johns Hopkins University; she has worked also in the Hygienic Laboratory of the United States Public Health Service and in the Psychiatric Institute of New York Hospital. From the laboratory of chemical hygiene in the same school have come reports of investigations by Dr. Margaret MacDonald. Dr. Ida Pauline Rolf is a member of the department of chemistry at the Rockefeller Institute for Medical Research. Mariana T. Sell,

assistant in agricultural chemistry at the University of Wisconsin, has been conducting research on vitamines. Hilda M. Croll is engaged in medical research at the New York Postgraduate Medical School and Hospital. In many other laboratories women are working on research problems in physiological chemistry, as advanced students and as paid assistants.

The research chemist must have graduate training; success demands a broad outlook and appreciation of the problems of physiological chemistry, a willingness to serve a long apprenticeship in preparing for any worth while research work, "an excellent scientific training and a really *good* scientific mind."

Dr. E. V. McCollum of the Department of Chemical Hygiene of Johns Hopkins University, School of Hygiene and Public Health, has said that "very few people are fitted for research, either men or women, and it is unfortunate to encourage anyone who is not thoroughly capable to enter this field. If we had one-tenth the volume of original publications that we now have, and they were all written by competent workers, the situation would be much better than it is.

"I may say very briefly that the problems in the field in which I am working are of two-fold nature: a study of the chemical nature of the vitamines, and further refined studies on the nature of the proteins; and a study of the relation of the diet to the production of pathological conditions. It will take years of effort for one to become able to work in this field. I do not know how long the field will offer attractions. One phase after another of chemical, physiological and other subjects are worn out and new eras are ushered in in every field of science. The opportunity now is good, but most people working in this field are making a sad failure of it. I do not intend to encourage anyone to take up research unless he shows extraordinary ability.

"There is never going to be much demand for chemists in investigational work in the field of nutrition. There is a great demand for competent women in teaching and in practical dietetic work, but I know of only two or three women in the whole country who are competent. Women have just as good an opportunity in chemistry or in any other science as men have if they will get down to brass tacks and master the subject, but you need not expect very many to do this."

Other chemists have emphasized the high qualifications necessary for research work in physiological chemistry as follows:

"I should say the woman who has the innate mental qualifications for a successful research career in chemistry is an extremely

rare product. For those who are willing to do routine work, on the other hand, the field offers fair opportunity.

"For a research worker there are necessary a keenly analytical mind and good critical ability; an unusually retentive memory, and the ability to correlate facts with problems; above all, the willingness to withdraw herself entirely from social interests and devote the best years of her life to uninterrupted study."

"The only limitation in research work lies in the capabilities and power of concentration of the individual. But for the woman of only average ability and moderate devotion to her work, very good assistantships are always available where good and increasing salaries are earned by conscientious attention to detail."

In conclusion, the following discussion of work in this general field by Dr. Lafayette B. Mendel, head of the Department of Physiological Chemistry at Yale University, offers valuable suggestions:

"For women who are trained in the essentials of chemistry, particularly in its quantitative aspects, who have some knowledge of organic chemistry, who appreciate the elements of physical chemistry, and who have had at least an elementary biological training, the additional mastery of the technique of modern clinical methods furnishes an opportunity for them to serve as assistants, or so-called technicians—if you like this degrading term—in a variety of types of laboratories. I find an increasing number of requests for properly trained candidates to fill such posts. If the candidates supply merely technical skill and do not have sufficient outlook (provided by a breadth of training) to appreciate the larger significance of the work in which they are engaged, such jobs are merely money-making devices which will rarely contribute more than a temporary satisfaction to those concerned. I presume there are many women who could advantageously employ such opportunities for earning a living and serving a useful purpose in everyday affairs.

"For the more ambitious young woman, who is not content to stick to the routine of an analytical desk, there are particularly promising opportunities in the investigation of problems in nutrition. You are doubtless aware that much of our best work in nutrition at the present time is being contributed by women. There is scarcely any department of the science of nutrition, whether it be the energy aspects, the utilization of foodstuffs, their metabolism, the chemical nature of the nutrients, the nature and significance of the so-called accessory food factors, in regard to which women could not and have not made creditable contributions. The important point to be emphasized, however, is that success in this more

elite field of endeavor requires something more than mere technical experience. It necessitates a broad outlook and appreciation of the problems of physiology and physiological chemistry, some sympathy with the aims of modern medicine and the public health movement, and a willingness to serve a long apprenticeship in preparation for any worth while investigational work. For highly trained persons there are promising opportunities. For the mediocre, or those who are in a hurry to land a job, the outlook is unpromising. Therefore aside from those who are content to be 'technicians' I should encourage only women who have the enthusiasm and persistence to enter a long training, and sufficient intelligence to think for themselves."

It is probably true that the demand for chemists in investigational work in the field of nutrition will never be for large numbers. The supply is not sufficient, however, to meet the limited demand since this demand is decidedly for competent and thoroughly trained chemists. It is also true that for the teaching of nutrition and for the practical application in dietetic work, highly trained physiological chemists are sought in larger numbers than can be found.

The same situation holds for chemistry as related to medical research in general. While the field of physiological chemistry is limited, it is one in which the number of positions is slowly increasing and in which the need for expert workers is by no means satisfied. For well-qualified chemists who will secure adequate training it offers, therefore, good opportunity for interesting and valuable work and for satisfactory advancement.

KINDS OF LABORATORIES

LABORATORIES IN HOSPITALS[1]

In the organization of a hospital laboratory it is customary that a physician be in charge. Only one who has taken the complete medical course can command the confidence of the hospital staff and understand as a whole the pathological problems for whose solutions the laboratory findings are desired. A laboratory is not considered to have the same standing and repute unless it is under the direction of an M.D. There are, however, exceptions whose number may increase with the growing importance of chemistry in diagnosis. Trained chemists are found in charge of these laboratories, especially now in smaller hospitals.

[1] For the number of hospitals in the United States, with location and description, see American Medical Association Bulletin, May 15, 1921.

The hospital chemist who looks forward to professional advancement has, however, in general to choose between two lines of preparation. If she looks forward to the directorship of a hospital laboratory she is wiser to choose the medical course. If her primary interest is *chemistry* she should prepare for the doctorate in that subject; with this preparation her future probably lies rather in assistant hospital positions, in research or in positions of responsibility in other laboratories concerned with related problems, such as board of health laboratories. For progress in *chemistry,* the medical degree is neither necessary nor advisable.

Hospitals are fundamentally similar but vary greatly in administration and organization. The following groups may be suggested although great variety will be found within each group.

General Hospitals. This group includes all public and endowed hospitals for general medical and surgical patients, and dispensaries and clinics which may be separately operated or connected with a hospital. Laboratories for clinical analysis are essential to all these institutions.

In the laboratories of many general hospitals important research work is also conducted. In hospitals associated with medical schools there is frequently greater stimulus for research and better provision for it, especially since individual members of the faculty of the medical school may be directing their own investigations in the hospital laboratories.

General hospitals may be large or small, well or poorly endowed, with a staff of physicians who may or may not be interested in research and in the scientific use and development of chemistry in diagnosis; upon these factors will depend the opportunity for chemists in the laboratories of these hospitals.

In general hospitals in all parts of the country women are employed as technicians, clinical pathologists, bacteriologists, chemists and research workers. In many of these positions important administrative duties are involved.

An example of a woman chemist engaged in research work in a hospital laboratory is that of Dr. Chi Chi Wang, head of the chemistry department of the research institute of Michael Reese Hospital in Chicago.

Special Hospitals. Special hospitals are usually devoted to the care of one kind of patients, those suffering from mental diseases, or from cancer, tuberculosis or diabetes and nephritis, for example; babies' hospitals and maternity hospitals also come within this group. Many special hospitals are established by the state,

others are endowed, and some are private institutions. Many have pathological laboratories and in a number of them very important research is conducted.

In these hospitals also women chemists are employed for clinical analysis. In a number of instances they are working on important research problems, for example, the use of radium in cancer, diseases of children, chemical aspects of tuberculosis.

Private Hospitals. Individual physicians or groups of physicians have established private hospitals and sanitariums for the use of their own patients. These hospitals may be limited to special diseases or may admit patients of all kinds. Investigations in physiological chemistry are conducted in many laboratories of private hospitals. At the Battle Creek Sanitarium Dr. Helen Swift Mitchell is director of research work in nutrition.

Hospitals in Industries. Many of the larger industries maintain hospitals and, in some instances, sanitariums for their employees. The number of laboratories in these hospitals is still limited. In some instances, a part-time worker is employed for both bacteriological and chemical analyses. For example, a woman who gives half time to a plant hospital is employed for the remaining time in the office of the physician who is medical director for the industrial plant. She describes her position as follows:

"I do chemical, microscopical and bacteriological work in connection with the medical department. The company employs over six thousand men and takes care of them free of charge. Not very much chemical work, but some. I do blood counts, sputum analyses, urinalyses, bacteriological examinations, make vaccines, etc."

The laboratory work for the plant hospital may be done also in some of the other laboratories of the industrial plant.

A woman trained in chemistry who was promoted from the analytical laboratory to be assistant to the research crystallographer in a large industrial organization has a small department of her own in which she carries out bacteriological examination of water and milk and does work for the plant hospital.

A chemist in the control laboratory of an abrasive manufacturing company does the analytical work, largely bacteriological, for the company's hospital. "The company maintains hospital rooms with five doctors in attendance at various hours during the day. In connection with their medical diagnosis of tuberculosis, diphtheria, anemia, etc., examinations are made."

Laboratories in Medical Departments of Life Insurance Companies

In connection with the medical examinations made by life insurance companies, laboratories are maintained similar to hospital laboratories. In one large company the laboratory staff consists, for example, of a head chemist, two assistant chemists and a technician. As first assistant chemist a woman in this laboratory wrote of her work:

"We are prepared to make any kind of bacteriological or chemical examinations bearing upon the diagnosis of disease; for example, we examine sputum, urine, and make chemical, bacteriological, serological and clinical examinations of blood, make vaccines, etc."

A chemist in one life insurance company has stated that the question, "Is there sugar in the urine and if so how much?" had been referred to and answered in the laboratory 500,000 times in the last 20 years and 35,000 times during the last 12 months. This has been an ever-present stimulus to perfect rapid, simple yet accurate methods of determining the presence and amount of sugar. Upon the answer to the question have depended the granting of insurance policies and the financial security of the company.

Laboratories in Institutions for Medical Research

Various important institutions for the promotion of medical research have been established, with which a limited number of women chemists are associated. How these institutions vary in organization and function may be explained by a brief description of several of them.

The Rockefeller Institute for Medical Research,[1] the largest and most prominent of these institutions, was established to advance the science of medicine through laboratory investigations and clinical observations and study in the hospital of the Institute. A department of animal pathology is also maintained. To the hospital department only such patients are admitted as are suffering from certain specified diseases which are from time to time selected for observation and treatment. At one period, for example, the following conditions were the subject of special study in the hospital and patients suffering from these diseases were admitted to the extent of the hospital facilities: acute lobar pneumonia and

[1] See Semi-annual List of the Publications of the Staff of the Rockefeller Institute for Medical Research.

other acute pulmonary infections, measles, acute rheumatic fever, cardiac disease, nephritis.

There are two departments of chemistry here, one connected with the Institute itself, the other with the hospital.

The Otho S. A. Sprague Memorial Institute in Chicago is also primarily devoted to the promotion of medical research. It operates, however, solely by supporting research in various existing institutions. At Rush Medical College laboratories for clinical research have been equipped by the Institute; at the Children's Memorial Hospital chemical and bacteriological laboratories have been established in which investigations of diseases of infancy and childhood are conducted; at the University of Chicago studies of the problems related to the treatment of tuberculosis have been carried on, as well as of the influence of heredity upon cancer. Research upon special problems in various hospitals and laboratories has been supported from time to time.

The staff of the Institute consists of a number of members who give their whole time to its work and of others who give some time to the practice of medicine. In addition there are special assistants and investigators.

Some of the problems of chemistry as applied to medicine are indicated in a brief outline of the present work of the Institute:

"One group is working on problems connected with the chemistry of tuberculosis and its treatment. Another group is studying chemical problems in relation to the subject of high blood pressure and related conditions. A third group is studying diabetes and related diseases. In each of these laboratories women are employed, but only two of them rank strictly as chemists. The work on tuberculosis is in charge of a woman, who is not a chemist, but has two men chemists working under her direction. There is no reason why any and all positions may not be occupied by women, as nearly one-third of our staff is composed of women."

The George Williams Hooper Foundation for Medical Research is closely associated with the University of California. The president of its advisory board is the president of the university, its director is professor of research medicine in the medical school. The institution is located in a building adjacent to the hospital of the medical school, a number of beds in the hospital are at the disposal of the Foundation and may be occupied by patients suffering from diseases which at the moment are the subject of study and investigation by members of the research laboratory staff.

Members of the Foundation offer elective courses to the medical students and a limited number of students may undertake research problems. Opportunities are offered graduates in medicine or special students who wish to enter upon a career of research.

The present work of chemists in this institution has been briefly described as follows:

". . . We employ chemists from time to time in our laboratory. As a rule we have been very fortunate in procuring the services of graduate students who had a thorough training in biochemistry and in chemistry as applied to dietetics and nutrition. Some of our assistants in chemistry received their training in the laboratory, having entered the institution after graduation from the high school. These statements particularly apply to the women working in our laboratory.

"The following problems are being investigated in which assistants in chemistry are used:

1. The use of the hydrogen electrode in its applications to the study of bacterial metabolism.
2. The biochemistry of anaerobes, in particular B. botulinus.
3. Gas analysis of the products produced by anaerobes.
4. Blood chemistry, routine procedures.
5. Influence of diet on the regeneration of haemoglobin.
6. The chemistry of chaulmoogra oil and the preparation of esters of chaulmoogric acids.

"It is the intention of the institution to organize, if in any way possible, in the very near future, a division of biochemistry."

The Carnegie Institution of Washington[1] maintains among other activities, a laboratory in Boston devoted to investigations in nutrition. An excerpt from a recent report of this laboratory suggests the range of its work: "The researches during the past eleven years have included studies of the metabolism of normal men and women, of children from birth to puberty, of diabetics, and of cold-blooded and warm-blooded animals. Observations have also been made on the influence of various factors upon metabolism, as the ingestion of foods; the breathing of oxygen-rich atmospheres; variations in temperature environment; muscular activity; pregnancy; fasting; obesity; rectal feeding; drugs and moderate doses of alcohol. . . . Studies have been made on the

[1] See list of Publications of the Carnegie Institution of Washington.

composition of outdoor air and on the exact determination of sugar in diabetic urine. The heats of combustion of a number of organic compounds and so-called 'extra foods' have been determined and analyses have been made of various diabetic foods."

The Carnegie Foundation has also cooperated in establishing the past year a Food Research Institute at Leland Stanford University with divisions for the study of the physiology and chemistry of nutrition and the chemistry of food manufacture as well as the economics of food distribution and the related general problems of agriculture and retail marketing.

A subcommittee of the Division of Biology and Agriculture of the National Research Council has recently formulated a program for a National Institute of Nutrition.

Other institutes and laboratories concerned with the problems of this field are: the John McCormick Institute for Infectious Diseases in Chicago; the Mayo Foundation in Rochester; the Nelson Morris Memorial Institute for Medical Research of the Michael Reese Hospital in Chicago; the H. K. Cushing Laboratory of Experimental Medicine at Western Reserve University; the John Herr Musser Department of Research Medicine of the University of Pennsylvania; the Bender Hygienic Laboratory at Albany and the Harriman Research Laboratory at the Roosevelt Hospital in New York.

For the study of special diseases there are additional facilities in institutes, laboratories, funds and foundations such as the Dermatological Research Laboratories of the Philadelphia Polyclinic, the James Buchanan Brady Urological Institute of the Johns Hopkins Hospital, the Russell Sage Institute of Pathology.

For the study of cancer there are the George Crocker Special Research Fund at Columbia University, the Huntington Funds for Cancer Research at the Memorial Hospital, New York, and at the Harvard Medical School, the Cancer Laboratory of the New York State Department of Health at Buffalo and the Laboratory of the Barnard Free Skin and Cancer Hospital at St. Louis.

For the study of tuberculosis, among others, are the Henry Phipps Institute at Philadelphia, the Trudeau Foundation for Research and Teaching in Tuberculosis at Trudeau, New York, the Research Department of the National Jewish Hospital for Consumptives at Denver, the Kenneth Dows Fund for the study of tuberculosis at the Johns Hopkins Hospital.

A number of women chemists have been working on research problems in these various institutions. For example, an assistant in biological chemical research with a year's graduate work in

physiological chemistry is a helper in work on "problems in physiological chemistry, some applicable to medicine and metabolism, also problems in chemical methods."

More independent is the work of another chemist in a similar institution: "A problem is assigned to me, materials and assistance are supplied. Advice may be obtained from the director when desired." The preparation which has led to such freedom in research consisted of a medical course supplemented by three years of graduate work in chemistry.

A chemist in an institution for medical research discusses as follows the work of her department:

"The work of the department of chemistry consists in the investigation of the constitution and structure of various materials found in the animal body, especially of such materials as are basic cell constituents. These problems are approached from the point of view of organic chemistry.

"My work is entirely of a research character and is to a great extent independent, although of course it must be subordinated to the interests and policies of the departments of the institution.

"I have had occasion to apply absolutely everything I have ever learned in the course of my work, although I suppose I have used more organic chemistry than anything else. A thorough grounding in physics, chemistry and mathematics, also as much general scientific knowledge as possible is to be recommended as the best preparation for this work; the rest one can acquire as one goes along. . . .

"The work which we can assign to technicians varies in character. Numerically, the greater number have been primarily analysts. Some, however, have been engaged in the synthesis of organic compounds of varying types. The latter work gives a very varied and thorough training for any girl who is anxious to do any kind of work dealing with organic chemistry. The salary of the technicians in the department ranges between one and two thousand dollars, according to their experience and work. Actually, however, a girl who displays aggressive ability, initiative and capacity for research, has a very fair chance of graduating from the class of the technicians into that of the staff workers, where her further rise is limited only by her own ability.

"My own work at present consists in investigation of substances (technically called lipoids) of a fat-like nature, found in all living organisms; these substances are found predominantly in the nervous system, although to some extent they occur also in the other organs of the body. One immediate aim is greater knowledge of

methods of isolation and purification of these substances. Ultimately this information will be of use to medicine for purposes of chemo-therapy. Many pathological conditions are accompanied by, if not caused by, imperfect relations in the quantities of the fundamental 'building stones' of the body, still other diseases are characterized by their disintegration to a greater or lesser extent. It is only by a thorough and correct knowledge of the structure of these important substances that we can hope to know their function, or to regulate them when the body mechanism fails to do so."

PRIVATE LABORATORIES

Physicians' Laboratories. Many practicing physicians maintain private laboratories, usually for analysis, sometimes also for research. Such laboratories are less frequently maintained by general practitioners than by specialists, in diagnosis, particularly, or in diseases like diabetes and nephritis. Several physicians may combine in supporting a laboratory; a physician may also maintain a unit and employ a worker within the laboratory of a hospital with which he is associated.

The most frequent type of work in these laboratories is a combination of chemical and bacteriological analysis. The character of the laboratories varies, however, and in some instances most important research work is conducted. Several outlines of women's work in such laboratories may be cited as illustrating the various possible situations:

In the laboratory of a general practitioner a woman is in charge, although her duties require but half-time employment; they include "general laboratory work—routine urinalysis, blood counting, some blood chemistry, some bacteriology."

A physical chemist is engaged in "research upon the physical-chemical aspects of certain physiological problems, particularly of shock and exhaustion," in the laboratory of a surgeon. She emphasizes the need of "broad and well digested" training—"one uses all he has and his progress is determined thereby."

A woman is employed as biological chemist by a physician who specializes in metabolic diseases. She writes: "My work is almost wholly chemical, consisting chiefly of blood and urine analysis. My employer has a metabolic unit consisting of a ward, a special diet kitchen with a trained dietitian, and a laboratory located in the hospital. We do routine daily urine analysis and frequent blood examinations on all patients, and upon the laboratory findings the diet and treatment are based. The work is fascinating and there is continual growth and development. A woman with a year

of graduate study and experience in the pathological department of a large hospital has been given charge of the laboratory of a physician who is "a diagnostician of excellent standing and has a large practice. We have a very well equipped laboratory. I work up the cases in the laboratory, do whatever may be indicated or prove necessary to assist in his diagnosis and follow up the cases. I find myself called upon to do all kinds of laboratory work. As a result I have developed into a jack of all trades. A clinical laboratory includes chemical, bacteriological, clinical pathological, histological and often X-ray work, in all of which I have found it very convenient to become more or less proficient."

In another instance two diagnosticians have together employed a woman as "laboratory technician." She says of her work: "I make Wasserman and Noguchi tests daily. I make blood counts, analyze blood chemically, analyze urine, feces and gastric contents. I make autogenous vaccines, examine microscopic smears for bacteria, make tissue sections for microscopical analysis. Occasionally I assist as office nurse."

Independent Laboratories. Diagnostic laboratories are conducted also as an independent business enterprise. They offer in the medical field a service similar to that of the consulting chemist in the industrial field. The work in these laboratories is usually entirely analytical and combines chemical with bacteriological and microscopic analysis. The M.D. degree is undoubtedly a great asset to a person who conducts such a laboratory; it not only inspires confidence but makes possible a larger variety of pathological work. Chemists with experience in hospital laboratories are able, however, to operate with success independent analytical laboratories. The following instances are cited as illustrations of the experience of women in their own independent laboratories:

An assistant in a hospital laboratory had been given charge of the chemical division with the title of clinical chemist. She taught bacteriology and clinical pathology in the affiliated nurses' training school. This experience was excellent preparation for her present independent work. She writes: "I now have a laboratory of my own, where I do work in clinical pathology sent me by physicians. I also have an occasional pupil in my laboratory."

A woman who had done all the laboratory work for a group of physicians, and held for a year and a half a government position as junior chemist, analytical, opened an independent laboratory with a partner and an assistant. She says of her enterprise:

"We do the general routine laboratory work which includes blood counts, complement fixation tests, urinalysis, qualitative and quantitative identification of bacteria, the making of autogenous vaccines, gastric analysis, etc. We find that the doctors are calling more and more for laboratory work as an aid to correct diagnoses, especially the young physicians. A laboratory test is usually of no value alone, but when considered with the clinical findings is of great aid in a correct diagnosis."

Both a main laboratory and a branch in a hospital are maintained and their success has been sufficient to encourage the managers to open a second group of two laboratories in a neighboring city.

A woman physician with graduate work also in physiological chemistry and with experience in medical research has opened her own diagnostic laboratory. She calls attention to the fact that the director of a laboratory must be a good business woman as well as a good scientist.

IN LABORATORIES FOR INDUSTRIAL ANALYSIS, DEVELOPMENT AND RESEARCH

It is impossible to overemphasize the importance of chemistry in modern industry.[1] There are few industries in which chemical work of some kind is not absolutely necessary and even in these it can, as a rule, be used to advantage in developing new products, utilizing waste materials, improving the quality of products already manufactured, increasing the efficiency of the plant, etc.

Industrial organizations maintain laboratories for the control of production, for the development of processes and for research. The control laboratory is primarily for analysis; it is essential to the daily functioning of the plant. One of its important tasks is the testing of raw materials used in manufacturing the product of the plant, and of such supplies as coal, water, gas, oil, etc. The main function of the control laboratory is the continuous analysis of each lot of the industry's product—each pot of metal, for example, or each unit of output of soap or perfume or aspirin or catsup, in order to know the product, to insure even quality, to discover variations that indicate the need for plant adjustment and shortcomings in the process that need improvement. The control

[1] For a suggestive reading list on this subject see Clarence Jay West, A Reading List on Scientific and Industrial Research and the Service of the Chemist to Industry, pp. 36-41. Reprint and Circular Series of the National Research Council, Number 9.

See also Arthur D. Little, The Place of Chemistry in Business, The Journal of Industrial and Engineering Chemistry, May 1921.

laboratory may be called the analytical laboratory or the testing laboratory. Its work often also includes the investigation of customers' complaints and sometimes the analysis of a competitor's products.

Out of this analysis naturally grows much of the development work of the industry. Development, however, involves investigation—studies of defects in the product and of means of overcoming them with improvement of present processes; studies of the effect of the process on equipment and preparation of special compounds for permanent resistance to such action; investigation of new applications and improved uses of the product. While this is research work, it is confined to problems arising in immediate connection with existing industrial enterprises and involves the application of the principles of chemical engineering in the plant.

Development beyond this point depends upon pure research—the independent investigation of problems arising from commercial or from theoretical considerations, experimentation to discover qualities of elements not yet understood, to find new sources for desired basic materials, to learn new syntheses, with the all-important experimentation in the utilization of by-products and waste.

The following description of research was presented by a large electrical manufacturing concern in one of its recent advertisements:

"What is research? Suppose that a stove burns too much coal for the amount of heat that it radiates. The manufacturer hires a man familiar with the principles of combustion and heat radiation to make experiments which will indicate desirable changes in design. The stove selected as the most efficient is the result of research.

"Suppose that you want to make a ruby in a factory—not a mere imitation, but a real ruby, indistinguishable by any chemical or physical test from the natural stone. You begin by analyzing rubies chemically and physically. Then you try to make rubies just as nature did, with the same chemicals and under similar conditions. Your rubies are the result of research—research of a different type from that required to improve the stove.

"Suppose, as you melted up your chemicals to produce rubies and experimented with high temperatures, you began to wonder how hot the earth must have been millions of years ago when rubies were first crystallized, and what were the forces at play that made this planet what it is. You begin an investigation that leads you far from rubies and causes you to formulate theories to explain how the earth, and, for that matter, how the whole solar

system was created. That would be research of a still different type—pioneering into the unknown to satisfy an insatiable curiosity.

"Research of all three types is conducted in the laboratories of the company. But it is the third type of research—pioneering into the unknown—that means most, in the long run, even though it is undertaken with no practical benefit in view.

"At the present time, for example, the research laboratories of the company are exploring matter with X-rays in order to discover not only how the atoms in different substances are arranged but how the atoms themselves are built up. The more you know about a substance, the more you can do with it. Some day this X-ray work will enable scientists to answer more definitely than they can now the question: Why is iron magnetic? And then the electrical industry will take a great step forward, and more real progress will be made in five years than can be made in a century of experimenting with existing electrical apparatus.

"You can add wings and stories to an old house. But to build a new house, you must begin with the foundation."

Laboratories devoted entirely to research are not found in large numbers in connection with industrial plants. The National Research Council lists 526 industrial research laboratories[1] in a majority of which chemists are employed. Many of these are largely for development and in some cases carry control work also.

The field of industry is the one in which women chemists have as yet had the least experience; on the other hand it is one in which they are expressing the greatest interest.

During the war period when workers were difficult to secure, many laboratories for the first time took on women workers. It must be remembered that the number employed in any one laboratory was small, ranging from one to fifteen and averaging from two to five. Since opportunities for women in industrial chemistry had previously been so limited, women were ill prepared for this sudden increase in demand and although the demand was not excessive, it surpassed the quality of the supply; it is not surprising, therefore, that results were not in every case satisfactory. It must also be said that candidates were selected for these positions in many cases on a basis of little discrimination so that totally unqualified women were in some instances chosen. It has been a valuable experience, however, and though a small proportion of the women who entered industrial laboratories during the war have

[1] Research Laboratories in Industrial Establishments of the United States of America—Bulletin of the National Research Council, Number 16, December, 1921.

remained (perhaps 20 to 25 per cent), certain conclusions can well be drawn:

1. There is no inherent limitation which in any sense disqualifies women for analytical work in control laboratories in industry. This work is of supreme importance to industry and holds many inherent satisfactions. Although in many instances it partakes of the character of "routine" work, any analytical job offers a woman the opportunity of increasing expertness, of developing new methods, of preparation for research if she has the capability for it; in occasional instances analytical work will lead to an executive position in the control laboratory or, in still rarer instances, to the position of chief chemist, or to a responsible position in the production departments. While advancement within the plant is for the few, and the bulk of the work of the control laboratory is daily analysis, yet the general experience is always valuable.

2. In laboratory research work there is no inherent limitation for women.

3. In research which is conducted primarily for development, whose results have to be worked out on a plant scale and which implies an intimate knowledge of plant construction and engineering, women are limited, in some instances by the physical requirements of the work; in others, by their lack of training and experience, especially in mechanics, and in others still, only by the tradition which precludes women from production work.

It is possible that the physical difficulties have been unduly stressed and that the chief limitation is the tradition that industrial work is not woman's sphere. In other occupations which have been accepted as entirely suitable for women, nursing and library work, for example, the heavy physical work is managed by a distribution of labor which provides for assistants who are able to handle the work which is too heavy for women.

A woman who is interested in and wants to prepare for industrial chemistry may well secure some training in engineering and mechanics. This is usually more necessary for her than for her brother whose general training and experience have included more contact with mechanical apparatus. An associate superintendent of a public school system has pointed out that "the hand work taken by the girls is with soft and pliable materials: cloth, yarn, butter, milk, foods of various kinds. The girls need work with hard and resisting stuff for the strengthening of their muscles and their minds. The high schools complain very often that the work in

algebra and mathematics is too hard for the girls. Nonsense. It is too hard for some of the boys. The same is true of physics."

The limitations based purely on tradition can only be overcome through the quiet demonstration by capable and trained women of their ability to do the work.

4. Some kinds of industries naturally hold more physical limitations for women in development and general plant work than others. It would seem that those industries in which a large number of women are employed in actual plant operations would offer the best opportunity and future also for scientifically trained women, since obviously the plant operations here are within woman's capacity.

5. The fact that marriage so frequently takes women out of professional work is a deterrent among many employers. It is a question, however, whether women's tenure of an individual position is on the average shorter than that of men, who are moved to other departments or leave to accept positions elsewhere as a matter of course. Indeed a number of chief chemists have expressed a preference for women analysts on the score of their greater stability in this respect. It is not so much the probability of a shorter period of vocational activity which affects the value of a woman's service as the fact that in the case of some women the possibility of marriage has prevented a professional attitude toward the work in hand.

The sensible solution would seem to be that the woman chemist who expects to marry should be content with analytical work, give it her very best efforts and make it absolutely return to the employer what the effort to train her has cost. For the woman who is intent primarily on chemistry whether she marries or not, analytical work is also a good experience. But she must go on with advanced preparation either in chemistry itself, for advanced analytical work or for research work, or in chemistry and engineering or chemical engineering for plant operation. In the latter she will be the greater pioneer and must be prepared to meet pioneer conditions.

6. The character not only of each kind of industry but of each individual laboratory varies greatly in its attitude toward women workers and the opportunity afforded them.

7. Not all women are adapted to industrial work. Only those who are find satisfaction in it. At present it may be generally stated that the most frequent positions for them are in the analytical laboratory, as assistants to research chemists, and in intelligence

work—looking up sources of information in the science, abstracting scientific articles in various languages, conducting scientific libraries.

8. The present status of industry in general is one of slow recovery from depression. Future prospects depend upon many economic factors difficult to prognosticate. It seems safe to say, however, that the new era begins with a deepened appreciation of the relation of science to industry, a stronger reliance upon science for efficient methods so necessary in meeting keener competition of today, and for the new knowledge upon which industry progresses. There is much reason to expect a growing future in industry for the adequately prepared and capable chemist, whether man or woman.

Both because the experience on which to base judgments as to the future is so slight and because there is considerable desire to understand what woman's prospects in industrial chemistry are, the following sections will incorporate many expressions of the results of experience and of the judgments of employers, chief chemists and women with industrial experience. Where no women are cited, it is because the returns upon which this study is based brought no information in regard to women chemists in the particular kind of industry under discussion.

KINDS OF WORK

The organization of each industrial laboratory is unique in at least some features. In a large laboratory or group of laboratories with various divisions, there may be quite specialized assignments for individual workers; there may also be more opportunity for varied experience and promotion. A small laboratory may either undertake only control work or may also conduct some research with or without variety for the individual worker according to the scope of the work, the plan of organization, and the point of view of the management. The following analysis describes the various kinds of positions that may be found in the different types of industrial laboratories:[1] Assayers, metallurgists and microscopists, whose work is very closely related to chemistry, are also employed in many industrial establishments.[2]

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[1] See also William J. Hale, The Immediate Needs of Chemistry in America. The Journal of Industrial and Engineering Chemistry, May, 1921.

[2] See pp. 193, 194.

CHEMIST

This is a very general term which may be ascribed to the worker occupying any position in a chemical laboratory. It is not usually applied, however, to the assistant or analyst who has not the equivalent of college training in chemistry, nor is it usually applied to the *inexperienced* college woman. The increasing tendency is to reserve this term for the chief chemist, the consulting chemist, the expert analytical chemist, the research chemist.

ASSISTANT

This is also a very general term. It may denote the untrained helper who handles clerical matters, carries out simple operations such as weighing, taking specific gravity, etc., or makes simple mechanical analyses which have been learned in the particular laboratory.

The assistant may, however, be a trained chemist to whom are assigned specific subsidiary parts of the work in either control or research laboratory, such as the testing of ingredients, water determinations, etc.

Some of the administrative duties of the laboratory may be assigned to an assistant, especially to one who works definitely with a superior. For example, the assistant to the head of an analytical department makes some analyses but also does the clerical work of the department, including the distribution of samples for analysis and the collection of results.

ANALYST

The analyst, or analytical chemist, who may be designated simply chemist, is found most frequently in the control laboratory, where she may also be called control chemist. Analytical chemists are, however, essential in the research laboratory as well and a so-called research chemist may be primarily engaged in analysis.

In the control laboratory the work of the analyst may be quite specialized, as, for example, the daily analysis of like samples coming into the laboratory at the rate of one every fifteen or twenty minutes. This may become routine, especially where the pressure is such that no time is available for consideration of observations made in analyses or for working out new methods of analysis.

This routine testing may be learned by untrained, or slightly trained, inexperienced workers who follow prescribed methods and who acquire a specialized skill. There are control laboratories the majority of whose analysts have been taught on the job. The

trained chemist may often work side by side with those who lack fundamental training; yet the experience has far more value for the chemist who can assimilate the results of her work. The demand is increasingly for analytical chemists with at least a college training. There must always be trained chemists in charge of the control work, who can supervise, interpret findings, work out methods of analysis, and make recommendations for corrections and improvement in the process.

Specialization in analysis does not necessarily imply routine work. Whether it becomes so or not depends in great measure upon the taste of the worker; for one who has interest in securing highly accurate results, in working painstakingly and with detailed care, the work of the analytical laboratory brings both satisfaction and promotion. The trained chemist spices the routine also with the search for new or improved methods of analysis.

Whether analytical work becomes routine may depend also in some measure upon the content of the work, which varies largely in different industries and in differently organized laboratories. How wide this variation is may be illustrated by the following paragraphs from women chemists' descriptions of their own work in various control laboratories:

"Simply chemical analysis of steel—routine."

"Not strictly routine work but more or less varied and in general up to me."

"My position is in what is called routine laboratory work but I have had an opportunity to work on a variety of products by being moved from one job to another; I have analyzed ores coming to the plant for zinc, have tested hydrochloric acids, zinc chlorides, salt cake for impurities such as iron, sulphur, lime, magnesia, etc., and have run zinc on zinc dust by the hydrogen solution method."

"Analytical chiefly—more ore alloys than any other one thing, but a great variety: paints, soaps, insulating materials, lacquers, papers, asphalt, ores, chemicals for acceptance."

"Standardization of all solutions used in two laboratories and of oleum shipments; new methods of laboratory procedure, analysis of competitors' products, raw materials, etc."

"My work was entirely in the laboratory, analysis of materials used in lamps, coal used in various plants, lubricants, steel, tungsten, cement, shellac, etc. In this laboratory the variety was very great, and as the laboratory was comparatively small it was not the deadly routine that exists in large, organized laboratories."

"I handle the entire control on the manufacture of oxalic acid—raw materials, intermediates and finished materials. In addition I handle laboratory experiments on plant research especially with regard to the materials actually made in the oxalic plant, or those which there is some likelihood of our making. Occasionally other plant research is given me."

The duties of the analytical chemist may include some research or be so arranged as to leave time for independent investigation. Of 47 women analysts in industrial laboratories who have reported on their opportunity for independent research, 28 find their situation favorable in this respect, although 19 qualify the statement in some way—time is inadequate, since the technical staff is small and needed for the regular work of the laboratory; there is too little time for anything not of immediate importance; in slack seasons only is time found; research is confined to the subject matter of the industry concerned, or to the fields approved by the director; or research is directed only towards devising new or improved methods of analysis. In some instances the analysts cooperate in working on problems with which the research department is engaged, and in others some research is undertaken in the analytical laboratory.

It is evident that the analytical work of an industrial control laboratory is the steady, necessary, everyday task. It requires a large number of workers not all of whom can be promoted out of the analytical laboratory in the immediate plant. The analyst is indispensable to successful production and is an integral part of the industrial organization.

With training in the control laboratory the possible lines of progress to which the *trained* analytical chemist may look forward are to the position of:

Expert analytical chemist
Field chemist
Research chemist
Head of a division
Chief chemist, director of laboratories.

Experience in the control laboratory is also valued as preparation for executive positions in production departments—plant operation. In many plants the laboratory is definitely considered a training school for such positions. It is this direction which promotion takes for men in the majority of cases rather than the direction of purely scientific work.

Work in the plant has not been considered suitable for women because (1) it is often of a nature beyond the physical develop-

ment of the average woman, (2) it involves dealing with plant foremen and operators, (3) it often necessitates night work, (4) it is often dirty. Only when women in general prepare for and enter engineering and production work and as the tradition against such work for women disappears, will women chemists, like men, be promoted from the analytical laboratory into executive positions in production departments, such as foreman, operating chemist, and the like. In this development women will find which forms of industry, if any, are not possible for them because of physical limitations.

Already women have demonstrated in a small number of cases that the limitations cited above do not always hold. For example:

A woman chemist who is assistant to the plant superintendent has directed the shop work and handled the unskilled labor in the shop. She feels the need of training in mechanics and engineering.

In a small pharmaceutical manufacturing plant a woman chief chemist is also factory superintendent.

In a large food product company a woman who is chief chemist is in charge not only of various laboratories but also of production in several plants.

A woman who had tested flour in a mill laboratory for several years is operating and managing her own bakery.

Experience in the control laboratory is counted excellent preparation also for positions in the purchasing and sales departments, since it gives a comprehensive working acquaintance with the products of the industry and with all materials used.

Expert Analytical Chemist

Specialization in analysis leads to important work. A certain metal manufacturing company, for example, counts among its most valuable employees an analytical chemist whose findings have been so painstakingly reached and found so reliable that the company is willing to lay them before any court. Another company which constructs machines, depends constantly upon the copper expert in the chemical laboratory since fifty varieties of copper and its alloys are used in constructing the company's products. Of similar importance to this industry is the steel expert. The expert analytical chemist is a specialist whose accuracy is absolutely reliable.

It is frequently true, also, that analytical work brings the best opportunity for seeing variations which lead to important investigations and discoveries. This can happen only to the trained chemist who has a background for judging what he observes.

FIELD CHEMIST

In connection with an industrial plant it is often necessary to send chemists out to do field analyses, especially in evaluating new prospective sources for raw materials. This may involve an exploring expedition to any part of the world and since a certain standard of living and social conditions can not be guaranteed, women are not usually chosen for the promotion which such an assignment means. For example, a woman who has worked in oil and gas analysis for several years with steady increase in efficiency and salary was making parallel progress with a man who entered the laboratory with her. When the employer had occasion to send a chemist to South America to study some new oil fields, at decided increase in salary, it was the man who was chosen. A corporation which has sent chemists to western Africa as well as to South America to study new prospective ore fields does not consider such enterprises suitable ones in which to include women workers.

It is worthy of note, in this connection, that in other similar enterprises women have successfully been included. For example, in the recent Akeley expedition of the American Museum of Natural History to the African jungles; in the Harvard Southern Astronomical Station at Arequipa, Peru; in missionary stations in all countries.

Rarely is a chemist assigned to do field work exclusively; it is rather a job which may cover a few days or weeks or years and which may be assigned in the course of regular laboratory work. It is always a promotion, for the field worker must be a chemist of experience in accurate work whose judgment is absolutely reliable.

RESEARCH CHEMIST

In pure research the chemist devotes herself to scientific problems to the exclusion of immediate administrative or business interests. As has been indicated, the industrial laboratories for pure research are few. In the majority of instances the problems chiefly concern development and involve a knowledge of plant operations and of business values, as may be illustrated by two quotations from chemists engaged in development work:

"In our own laboratory, for example, our research men must follow a successfully developed process through the early plant stages, and keep in touch with the process for a considerable time after it has actually been turned over to the plant operators. Often a research man is transferred to the plant to take charge of the particular process which he has developed."

"In industrial research, besides the study of the chemical reaction concerned, the chemist has to investigate quantitatively from the point of view of cost, and this dual aspect of each problem calls on the one hand for originality, care and assiduity, and on the other for the use of the imagination and application of common sense, qualities not produced by education alone but possessed only by men of best brains and ability."

The number of positions in the field of research is much smaller than in control analysis. It is also probably true that a limited number of persons are temperamentally and by native ability adapted to research work, which requires a patient, experimental, discriminating, creative mind, and which shows results only after a background of long experience has been built up. Research is directed by leaders of such ability and such experience, whose projects are carried out with the help of chemists who work more or less independently.

On the other hand, the demand for research chemists in industry has been greatly stimulated by the extension of operations into new lines, especially the manufacture of chemical products, by the effort to secure higher efficiency of production, and by some conspicuous discoveries of great practical importance to industry by university professors whose contact with industrial chemistry brought about by war conditions was an entirely new experience. As a result, industry has been calling more persistently and for greater numbers of *thoroughly trained* and experienced research chemists.

Laboratory research holds no limitations for women and offers the best opportunity in industrial laboratories for them today. The limitations in regard to plant work are considered to hold also in research work which involves going about in the works, testing on a production scale the conclusions reached in laboratory research, or working out development plans which involve a practical mechanical ability and engineering knowledge.

Examples of descriptions of the work of women in research laboratories in industry follow:

"Always very varied. One important problem may occupy all one's time for several months while lesser ones are settled more quickly. For example, the company proposes to set up a plant to produce a new by-product. It is necessary to determine the best conditions for performing every step in the proposed process. Or a use may be sought for a by-product that is a white elephant, etc., ad infinitum. The chief chemist is very glad to have the chemists

under him put forth their own ideas and develop them in their own way."

"Various investigations, mostly of an analytical nature; also analysis of certain samples which can be handled more effectively in the research department than in the testing laboratory."

"Research on the synthesis of new compounds; working out the processes to be taken to the factory; working out research problems for customers."

"The laboratory is a branch of the research department started during the war to supply rare organic chemicals to this country. My work is making these rare compounds on a laboratory scale for greater purity. I work out methods of preparation and have assistants of only slight chemical training to carry out the routine preparations. Very few of the compounds we are called upon to make have well-known methods of preparation. A great deal of my work is finding out satisfactory methods of making a given compound."

"I work as one of two assistants to one of the leading research workers of the company. He is too busy to conduct experiments himself on physical chemistry and I do these under his direction. The problems investigated are partly 'pure' and partly commercial research, e.g., I have worked for several months on the behavior of oils on solid surfaces, a problem arising from theoretical considerations. I am now working on a problem of mineral separation in mining. My work is more 'pure' research than commercial, as commercial problems are taken up only when interesting from a theoretical standpoint. My chief explains a problem to me and the way in which he believes it should be attacked and then leaves me alone to carry out my own ideas."

HEAD OF A DIVISION

In a large laboratory the administration is frequently subdivided, with a separate head for control and research laboratories, all under the chief chemist or director of laboratories.

The control laboratory itself may also be grouped into divisions, each with a head. Such an officer may be in charge, for example, of the control work on a new product; or, in a highly specialized laboratory, of one detailed analysis, as of steel for carbon.

The following are examples of various supervisory positions in connection with control work:

In an iron plant, a woman is in charge of the laboratory where analyses are made for silicon, manganese, sulphur, phosphorus, and total carbon, of samples of iron sent in daily from the various plants

of the company. Each car of pig iron or coal used by any one of the plants is analyzed in the laboratory; in addition research is conducted in cooperation with the research department.

In a specialized textile plant a woman chemist is in charge of dyestuffs and water. All samples of dyestuffs submitted are tested, all shipments of dyestuffs used are tested, daily analysis controls the condition of the water used in dyeing, various problems in dyeing are solved and new methods of procedure are developed.

Under the head of the laboratory department, a woman is director of analytical work in a milk products plant; she is in charge of the direct analysis of condensed milk in the main laboratory and watches the reports of twenty-five plants.

Large research laboratories may also have separate divisions. One group of laboratories, for example, has divisions for physical and organic chemistry. Under the director of development and research, heads of these divisions carry large responsibility. For example:

A woman research chemist with experience in the analytical laboratory as well as in research is in charge, under the general direction of the head of the entire research division, of an experimental plant dealing with the problems of deleading zinc ores.

In an electro chemical plant one of the research interests is the bleaching and finishing of textiles. Under the general superintendent of the bleaching station a woman chemist is in charge of a small laboratory for the analysis of samples and the solution of problems sent in by customers of the company, and of a bleacher with laborers to handle larger lots in the model bleachery.

There are heads or supervisors or chemists in charge also whose responsibility is the distribution of work, the ordering of supplies, etc. The following is an instance of an important position of this kind:

In a large laboratory a trained woman chemist is in charge of the stockroom of chemicals and apparatus, the ordering of all new stock and of special apparatus for research work. About 120 chemists use this storeroom for supplies. The chemist is the head of the force of two men and two boys who receive and distribute new material, and of two girls with whom she handles all cost figures for research jobs and all correspondence in regard to storeroom supplies.

CHIEF CHEMIST

The chief chemist is the director of the chemical laboratories of the industrial plant and the scientific adviser of the management on matters concerning control of production, development and research. He must know thoroughly the mechanics on which the industrial application of chemical processes depends. The scope and responsibility of this position vary with the size and organization of the industry. In one plant the chief chemist may be the only chemist, in charge of all chemical work with but one helper. Again he may be the director of an involved section including experimental research and control laboratories. Between these extremes is an endless variety in organization and extent of laboratories for which the chief chemist is responsible.

The work of the chief chemist will depend somewhat also on the stage of development of the industry. Production methods may be satisfactorily established and an analytical laboratory for control only be maintained. If the process is a new one and there is interest in perfecting scientific methods and developing by-products, the laboratories will include research as well as control work.

The chief chemist may be the main factor in the settlement of important disputes in which his company becomes involved, in regard to patents, quality of product, or quality of raw materials.

It is evident that the requirements of this position demand not only an expert chemist, but also an able administrator. The title may be director of laboratories, or, in some instances, consulting chemist.

Women are found as chief chemists in only isolated cases, so far. They have had but little experience in industrial laboratories, very few have shown ability and taste for the closely related engineering methods involved in production problems. While their fitness for laboratory work is granted, there is the tradition already referred to that women are not adapted to going about the plant, working with plant equipment, supervising laborers, etc. There are, however, examples of women who are carrying the responsibility of chief chemist, which prove that in some kinds of manufacturing plants, at least, there are no inherent limitations to hinder the progress of women to this administrative position. Several instances follow:

In a paper manufacturing company a woman as chief chemist has charge of a laboratory force of eight; about one-third of the time is given to certain control tests such as flue gas, bleach production, wax extraction tests, the remainder is on research work.

Perhaps one-third of the time is for short problems for temporary needs, the remainder for longer researches for publication. Her own time is almost entirely given to directing and reporting and outlining the work; occasionally she finds time for qualitative testing to start some new work.

In a plant which manufactures toilet preparations a woman in the position of chief chemist supervises the process. She has developed formulae for new products and has every opportunity for research.

In a small ink manufacturing plant a woman in a similar position had control of all manufacture of printing inks, tested all incoming supplies and worked with heads of each department over any difficulty which arose.

In a medicinal laboratory a woman chemist has charge and supervision of the manufacture of all glandular products.

The chief chemist, a woman, in a plant manufacturing storage batteries, steel shells and cylinders and acetylene, has charge of all analytical work, largely inspection and analysis of raw materials, plant control of chemical processes, and research of a chemical nature on storage batteries.

Assistant Chemist

This usually means assistant to the chief chemist. A person in this position may have charge of the general laboratory work on one shift, where the process is continuous, and in turn be subject to the chief chemist who exercises general supervision.

A woman who is "assistant chemist" in a laboratory employing twelve people has charge of the laboratory in the absence of the chief chemist, does some control work, analyzes anything the superintendent may send in, works out methods, checks up the daily work, standardizes solutions—"just any and everything which comes up."

Consulting Chemist

A consulting chemist usually has his independent laboratory. He is called upon by various industries to make special analyses, to work out special problems or to submit plans for construction or operation. He enters a plant entirely unprejudiced, which is his great advantage.

The consulting chemist usually specializes, at least to some extent—in paper, for example, or rubber or dehydration. One firm of consulting chemists specializes in textiles and does the testing

for a textile trade association. A well-known consulting chemist has made a special study of the management and organization of laboratories for industrial corporations. His work has been for the most part the interpretation of chemistry and chemical research for executives in industrial plants.

A consulting chemist may be the decisive neutral party in controversies concerning the quality of raw materials. At one plant, for example, three samples are always taken of raw materials; one for analysis, one for reserve in case of accident, one to send to a consulting chemist in case of a dispute between the seller of the material and the buyer as to a fair cost price.

Women have as yet too little experience and prestige in industrial chemistry to warrant the establishment of such independent service. No record has been found of a woman consulting chemist.

CHEMICAL ENGINEER

The chemical engineer is rather an executive than a chemist, although he must have a training in chemistry which is sufficient for a complete understanding of the processes of the industry with which he is connected. As an *engineer* he must further be able to design and install equipment, repair broken or worn apparatus and solve the engineering problems of industries whose processes are chemical. The demand for chemical engineers has arisen because of the need of a technical staff, combined with the inability to supply a complete staff with the various requisite specialties all represented. A technical school in which chemical engineers are trained makes the following statement concerning the work of the chemical engineer:

"The opportunities for promotion that come to the young chemical engineer vary greatly with the character of chemical manufacturing that he enters. In a large establishment, he may have to take up routine analytical work in the laboratory, serving a sort of apprenticeship, proving that his work is accurate and that he can be relied upon. From the analytical laboratory he may be promoted to the research laboratory to a position in charge of a department in the plant, or to the position of chief chemist or chemical director, in the latter position having charge of all research work and outlining the methods of manufacturing. Positions higher than these as to authority and responsibility are, assistant and general superintendent, general manager, etc.

"There are now many establishments in America of moderate capital engaged in manufacturing based on chemical processes,

which in the early stages of their history cannot support a complete technical staff. For this type of plant there has arisen in late years a great demand for young men with just the training that is given in a course in chemical engineering. The advancement of the young chemical engineer in such a plant is even more rapid, as a rule, than in the larger establishments noted above, for the reason that he fills from the very beginning a more important position in the affairs of the company. Such a man is at the same time the chemist (devoting a part of each day to chemical work), the draftsman perhaps for a few days at a time, the engineer planning the installation of new apparatus, or he may have to take up a research problem connected with some phase of the plant operation, and give it his entire attention. For the young chemical engineer in a position of this character, the rate of promotion depends entirely on his own character and ability; the opportunity is there, and all that his employers ask is that he measure up to the requirements."

With the developing recognition of the practical value of science to industry there is a growing demand for the person with concentrated scientific training in chemistry—the chemist, *and* for the engineer. The combination represented by the *chemical engineer* may be transitory, therefore, or may remain permanently in demand for smaller industries.

Although there are women chemists who feel from their experience that "chemical engineering is entirely possible for any woman with the force of mind and body to meet the conditions of the work and deal with different groups of people," the prevailing opinion at present is that this form of industrial work is least suitable for women. A consulting chemist of extensive experience expresses the latter opinion as follows:

"As regards chemical engineering, it seems to me that women are at such disadvantage that there is little probability of their being able to compete successfully with men. It is probably the most difficult branch of the profession and the most varied in its demands upon the knowledge, experience, and resources of the practitioner. These demands are often extended to include physical endurance. One can hardly hope to succeed without some years of actual plant experience, which often involve living in very crude communities. Breakdowns of equipment are common events, and long periods of continuous work are often required to put things right. During my first three years of plant experience I was many times called upon to work thirty-six hours at a stretch, and I have worked from Monday morning at seven o'clock to eleven o'clock

Wednesday night. In the general practice of chemical engineering much travel—often to remote localities—is frequently necessary. Our own men are almost constantly on the road. When it comes to construction there is the rough and tumble of contests with contractors and labor unions and the necessity of driving the work in all sorts of weather. Starting up a plant is always a period of severe strain and quick readjustments."

KINDS OF LABORATORIES

Laboratories for industrial analysis, development and research may be divided into two general groups: laboratories within individual industrial organizations, and independent laboratories which may be established by groups of industries, or which may be the private enterprise of a consulting chemist or a group of chemists.

LABORATORIES IN INDUSTRY

Any classification[1] of industries is necessarily overlapping at various points. In the following discussion, which is entirely suggestive rather than in any sense exhaustive, the industries are treated in large inclusive groups of related products, with the original materials used or similarity of general chemical problems involved as a general basis for grouping. The plan of the discussion is to give any available information which may indicate to the prospective chemist the extent of the industry and the relation of chemistry to its operations and future development. Where possible, lines of research which are pointed out as necessary, by chemists of experience in the field, are indicated. An account of women's experience in the laboratories of various industries is given in order to suggest more adequately the conditions to be met and to encourage better preparation on the part of women who enter industrial chemistry in the future.

The figures which are cited from the census of manufactures have no direct present indications for chemists; they merely suggest the extent of the industry and therefore the possibility of expanding opportunity for the chemist as scientific methods are increasingly accepted.

Abrasives. The manufacture of emery and other stone abrasive wheels is a mechanical process and does not involve chemical

[1] Various classifications were consulted: the census of manufactures; the scientific and engineering classification for laboratories connected with industrial establishments adopted by the Research Committee of the American Society of Mechanical Engineers; the commercial classification of laboratories connected with industrial establishments of the National Research Council. The result is a further condensation on the basis of materials used, as well as kinds of products.

control. With the electric furnace there have been developed, however, synthetic abrasives: silicon carbide, which is made as carborundum, carbolon or crystolon and a purified emery, sold as aloxite, alundum, exolon, lionite or coralox. The basic materials and by-products of these abrasives are also used as refractory material and the manufacture of abrasives and refractories is frequently combined.

The synthetic abrasive industry is limited in extent; there are probably not more than a dozen establishments engaged in the manuufacture of these materials. Each one, however, requires chemical control, for the process is a chemical one; in addition, research laboratories have been established as essential in the development of this new industry.

The laboratories in abrasive plants are concerned with the analysis of raw materials, such as clay, coal, shellac, rubber, oils, paraffins, silicate of soda and natural and artificial abrasives; with analysis of the manufactured product; and with investigations of raw materials, abrasives and the related ceramics.

Physical and electrochemistry are primarily concerned in this industry; organic chemists are also found working with glue, rubber, shellac and the like, used in making abrasive products.

Women have been employed both in control analysis and in research work in the abrasive industry and their value as analysts is indisputably recognized; there remains a doubt in regard to their suitability for research work due to the nature of the products handled. They have not been given an opportunity to become familiar with plant operations.

An analytical chemist in a plant manufacturing abrasives, refractory ware, etc., includes in an account of her day's work, analysis, qualitative and quantitative, of any raw materials used in any department of the industry, of manufactured products (control work), of competitive products. She considers her position as training for entrance into work concerning one particular phase of the industry, for example, the specialized study of clays, of insulating materials or of refractory substances. She writes in regard to women in chemistry:

"There are many who now grant that women are more careful and accurate analysts than men. Whether or not they are equally successful in other lines of chemistry remains to be stated by a more experienced observer than I. However, it is my belief that there are no insurmountable obstacles inherent in the nature of women which bar them from entering any branch of chemistry to

which they are attracted and for which they are fitted with regard to education and personality."

A research chemist in the research laboratory of an abrasive manufacturing plant is also occupied primarily with analysis. "The work consists of various investigations, mostly of an analytical nature, also of the analysis of certain samples which can be handled more effectively in the research department than in the testing laboratory. It is interesting and presents excellent opportunities for those possessing initiative." Her experience in the reasearch department, she expects, will serve as training for an executive position in the testing laboratory.

Adhesives. In 1919 there were 123 establishments engaged in the manufacture of mucilage, paste and other adhesives, 61 in the manufacture of glue (aside from those for which glue is a by-product) and 220 in the manufacture of blackings, stains and dressings, according to the figures of the census of manufactures.

The manufacturer of adhesives may be concerned primarily with glue and gelatin, or with a wide range of related materials: gums, starches, colors, sizings, finishings. A more complete understanding of the reactions that take place during the manufacture of glue, a material on which there is as yet little published data, is essential in order to control the process more adequately, to improve the methods of manufacture and to secure maximum yields and quality.

"An example of the problem to be met is to find a definite method of distinguishing hide glue and bone glue and determining the proportion in a mixture; to determine the compounds existing in various types and grades of glue and to control their production."

(Director of research in a glue company.)

Some of the larger research problems which have been pointed out as needing attention in this field are:[1] "Theory of adhesives. The whole theory of adhesives depends in part on the fact that the cementing material adheres strongly to the two surfaces and hardens there. It is, therefore, possible that one agglutinant may be useful for a number of different materials, such as wood, glass, metal, ivory, etc., while others give good results only with special materials. Since the books give different recipes for cements for glass, cements for metals, cements for metals and glass, etc., the differences in adsorption are real ones, though no one has

[1] Wilder D. Bancroft, Research Problems in Colloid Chemistry; Reprint and Circular Series of the National Research Council, Number 13.

ever made a careful study of agglutinants from this point of view. . . .

"Vegetable glues. There is practically no literature on the vegetable glues outside of a few patents. We need published research on the whole subject with special reference to peptization, viscosity, and adsorption.

"Waterproof glues. A waterproof glue of indefinite life is needed. . . . At present the best waterproof glues weaken in time, no doubt, because of the action of water on the protein material. A glue should be made that will not take up moisture after it has once dried."

In problems pertaining to adhesives it is the chemistry of colloids that is particularly applied; general chemistry, physical chemistry and organic chemistry are essential as fundamental preparation. Since this is an industry whose chemical reactions are little understood and whose scientific aspects are undeveloped, there is a moderate but steady need for chemists.

"Any undeveloped industry, such as this, is a field for chemists —that is to say, to make practical use of their knowledge in plant work; to do so they must take active part in the production end, and make their chemical training a means of gaining and improving plant supervision." *(Chemist in a glue company.)*

"As to the demand for chemists in our field I cannot conceive of a decreased demand and I think that everything points to a moderate but increasing demand."

(Chief chemist in the glue-works of a meat packing company.)

The laboratory work in this industry has been considered entirely suitable for women. There is a question, however, as to the desirability of plant work.

"The only limitation that I see to which women chemists must be subject is their adaptability to factory conditions as found by them. The majority of industrial chemists are, by far, plant chemists and the conditions under which they have to work may or may not be suitable or attractive to the woman chemist. As to their field in research laboratories, I think the only limitation is the individual's ability, but this applies equally to all chemists of either sex."

(Chief chemist cited above.)

"A man chemist may become general manager or superintendent and find his training of great value. Our purchasing agent also began in the laboratory. But a woman simply is not thought of for

such promotion. Of course, in the very large laboratories there would be a chance for executive work in the department. So choose well at first." *(Woman chemist in a cement plant since 1905.)*

A woman chemist in a plant in which are manufactured adhesives, ink, polish and oils has been making the routine tests and has carried on research work for liquid glue. Her employers have entitled her "full chemist" and consider her work very satisfactory.

In another plant a woman chemist analyzed varnish gums, liquid soaps, oils, inks, etc. Investigations were made for substitutes for expensive and rare materials, such substitutes necessitating a revision of all existing formulæ. She advises that physical chemistry is the key to all of this work, and that a knowledge of calculus is required for a full understanding of it.

Cellulose Products. The chief sources for cellulose are cotton and wood, its chief product, paper. A large number of other products have been developed comparatively recently, among the most important of which are guncotton, collodion, celluloid, artificial or fiber silk, leather substitutes, varnish and lacquer, photographic films.

The application of cellulose to various uses is one of the great problems for the industrial chemist of the future. It is primarily organic chemistry that is applied in a cellulose industry; a general knowledge of inorganic and especially of physical chemistry is, however, essential.

The chief of the research staff in the experimental station of a manufacturing company largely concerned with cellulose products points out that among the problems for research in this field are: 1. To find some use for the particular kind of nitrocellulose of which the large stocks of left-over cannon powder principally consist, or some method of treating it so as to make it suitable for use in the manufacture of the products named above. 2. To find a substitute for castor oil, used almost universally in the manufacture of artificial leather, which will not become rancid. Chemists have no definite knowledge of the cause or mechanism of rancidity development.

Celluloid. The pyroxylin plastics with a large variety of trade names, celluloid, fiberloid, ivorine, pyralin, etc., are the basis of a considerable industry. The processes involved are chemical reactions and must be chemically controlled. Coated fabrics, synthetic fibers, pyroxylin solutions, lacquers, are all closely related to these products and usually manufactured together.

Paper. The extensiveness of the paper industry in this country is indicated by the fact that the census of manufactures reported 714 firms producing paper and wood pulp in 1919, 718 firms in 1914. The product had increased in value from $332,147,000 in 1914 to $794,350,000 in 1919. This does not necessarily mean a gain in quantity of production, since the price of this particular commodity was so markedly increased in this period.

The variety in the industry is suggested by the census classifications of paper and wood pulp products: newspapers, hanging papers, poster paper, book paper (plain, coated, cover, plate), cardboard, bristol board, etc., fine paper (writing, etc.), wrapping paper, manila (rope, jute, tag), heavy (mill wrappers), straw, bogus or wood, kraft paper, tag stock (rope, jute, sulphite), boards (wood pulp, straw, news, binders, trunk and press board, leather), tissue, blotting, building (roofing, asbestos and sheeting).

Chemical control in paper mills covers not only the basic material, cellulose, but includes also the analysis of coal, sulphur, lime, caustic, clays, fillers of all descriptions, pigments and dyes, the utilization of lumbering waste, and other related matters.

A manufacturing company has recently printed in its house organ the following table, which gives the exact amount of each of the various materials which are used in the making of 100 pounds of paper:

Wood	13.4 cu. ft.
Sulphur	12.7 lb.
Limestone	17.5 lb.
Kerosene	5.7 oz.
Bleach powder	14.3 lb.
Rosin	3 lb.
Soda	.515 lb.
Alum	4.2 lb.
Color	1.8 oz.
Coal	320 lb.
Iron Sulphate	.79 oz.
Copper Sulphate	.19 oz.
Lime	3.17 oz.
Belt	2 sq. in.
Felts	32 sq. in.
Wire	67 cu. cm.
Lubricating Oil	220 cu. cm.
Water, chemically purified and filtered	7500 gal.

It was a well-known chemist who recognized the possibilities of scientific methods in paper making and who produced both the need and the men for the industry as a result of strenuous effort. Today

chemical control is recognized as essential and the need of further fundamental research is granted.[1]

From the secretary of a large paper company comes the statement: "In the paper industry the fundamental chemical reactions are not understood. For example, the chemical constitution of cellulose, and therefore the changes it undergoes both in the preparation of chemical pulp, in the cooking of rags, in the purification of other fibers, and in the bleaching are not known. The procedure is according to rule-of-thumb methods. We do not know whether there is any fundamental difference between the celluloses obtained from the various sources. We do not understand the chemistry of the rosin-sizing process, even though rosin sizing is necessary for all printing papers.

"As to the future demand for chemists in our particular field, this demand is growing, both for testing and for research. As more becomes known of the fundamental chemical nature of the materials and the changes they undergo, naturally more chemical control will not only be possible, but necessary."

The research problems which confront the paper industry, as stated by various chemists responsible for such research, are:

1. Studies on the constitution of cellulose; tests of various woods and fibrous materials; a critical study of new methods and reagents for isolating cellulose from wood or plant tissues.
2. Studies on the soda pulp process; destructive distillation of waste black liquor of the soda process and identification of products obtained; the preparation of useful products from this waste.
3. The preparation of useful products from the waste sulphite liquor of the sulphite process.
4. Bleaching studies on sulphite and soda fiber to show the effects of variable factors.
5. The development of a test for sulphur in paper.
6. Studies on rosin sizing; tests on factors influencing the rosin sizing of paper.
7. Studies on the solubility, adhesive strength and viscosities of caseins and their solutions and coating mixtures.
8. Studies of the expansion of papers with increasing humidity.
9. Studies of defects in papers and of means to overcome them.

[1] See Paper, October 19, 1921. Pulp and Paper Magazine, October 20, 1921.

10. Problems relating more directly to paper mill operations along the lines of improving processes, finding why things go wrong, etc.

Paper mills employ large numbers of women operatives and it would seem that the inability of women chemists to do plant work would be at least modified in this industry. The limitation does nevertheless hold in the minds of employers.

"I consider that there are decided limitations for women chemists in the paper industry because so many of the problems require a knowledge of actual manufacturing operations which can only be obtained by working with the processes on a large scale and among the men in the mill. Lack of such practical knowledge would make it very unlikely that the research work would be crowned with success. For routine work in testing and analysis women should prove quite satisfactory, though I prefer men because they can be sent anywhere in the mill for samples or information and are therefore more generally useful.

"It seems to me that the outlook in chemistry as a vocation for women should be good in certain lines where they are not obliged to work in the actual manufacturing operations."

(*Research chemist in a plant manufacturing pulp and paper.*)

"Women chemists may very well do for some types of research work and may do testing. As to mill control, this is out of their field, because it often involves unpleasant, dirty and sometimes heavy work, but chiefly because it involves a close cooperation with the men in the mill, who resent taking directions from a woman."

(*Secretary of a writing paper manufacturing company.*)

There are also the traditional subsidiary considerations, stated by a "technical director" in a paper mill, as follows:

"In the first place, women have physical handicaps which men have not. In the second place, when things go wrong in the mill the work required by chemists often extends over the time set by law in which you can employ women. In the third place, after having spent large sums of money in training the woman to fill the position, she is liable to get married and thus there is a dead loss to her employer.

"It costs the mill more to employ a chemist than the mill reaps for the chemist's services in the course of the year. This is true whether the chemist be man or woman.

"If the woman is going to leave, after a year or two, to get married, after the mill has borne all the expense of her training and

her mistakes, it is a losing proposition for the mill. I am speaking from actual experience as we have employed women chemists here. Our experience is that they are faithful and industrious, but these good qualifications are nullified by those mentioned above."

Yet women chemists are doing acceptable work in laboratories of paper mills and are finding satisfaction in it. In at least one case all the limitations cited above have not prevented the advancement of a woman to the position of chief chemist. This chief chemist briefly describes her work as follows:

"I have charge of a laboratory force of eight, three college graduates, two high school graduates and three with only mill practice. About one-third of our time is given to certain control tests, such as flue gas, bleach production, wax extraction tests, etc., the remainder is on research work. Perhaps one-third of our time is for short problems for temporary need, the remainder longer researches for publication. My own time is almost wholly given to directing, outlining and reporting the work. Occasionally I find time for some qualitative testing to start some new work.

"There is still much masculine prejudice to combat. Many laboratories are not attractive looking. We come into contact with working men, which may be construed as an asset or a liability. At present there is a desire to use women for the inside laboratory, detailed work, since *men prefer* the engineering end. Women are handicapped by lack of opportunities to come into contact with other workers and by lack of knowledge of engineering on which industrial application of every chemical process depends."

A paper mill chemist whose work is concerned chiefly with the reactions of cellulose in connection with mill problems—fiber study, photographic, microscopic and reactions to stains, with some work with waxes, oils, color, etc., and a small amount of control work, includes among the advantages in her position the opportunity to know the laboring man's problem on the one hand, and the chance to attend related scientific industrial organization meetings on the other. She finds, however, that "because of the few women in the field at present, there is a necessity of often standing alone among men, some of whom are still very conservative. Men chemists usually look forward to managerships; in the laboratory work the opportunities for advancement in position as well as salary are approaching equality."

Ceramics.[1] The ceramic industries are founded upon such substances as clays, earths, rocks. Their products are brick, tile,

[1] See the Monthly Journal of the American Ceramic Society.

cement, glass, pottery, china and porcelain in their many varieties. The American Ceramic Society classifies the following list of products as ceramic:

Structural Wares	Household Wares	Accessories Used in Dependent Industries
Common Brick	Bath and Laundry Fixtures	Fire Brick
Paving Brick	Sanitary Wares	Steamship Hearths
Face Brick	Bedroom Wares	Locomotive Slabs
Terra Cotta	Kitchen Wares	Tuyeres and Blast Furnace Fittings
Sewer Pipe	Porcelain and Earthenware	Basic Brick
Conduits	Pottery Ornaments	Insulators
Drain Tile	Cut Glass	Spark Plugs
Hollow Block	Table Glass	Glass Pots
Roofing Tile	Enameled Metals	Limes
Flue Lining	Filters	Plasters
Floor and Wall Tile	Bottles	Special Cements
Fireplace Tile	Lightning Glassware	Abrasive Wheels
Window Glass		Optical Glass
Skylights		Chemical Porcelain
Cements		Chemical Stoneware

The statistics for groups in the ceramic industries according to the census of manufactures are as follows:

	Number of firms			Value of Product		% Increase
	1919	1914	Increase	1919	1914	
Brick and tile, Terra cotta, Fire-clay products	2449	3239	—790	$211,693,000	$135,921,000	55.3
Cement	122	133	— 11	171,459,000	101,756,000	68.4
Glass	371	348	23	261,884,000	123,085,000	112.7
Pottery	339	350	— 11	74,884,000	36,943,000	102.4

Not a large proportion of plants in the ceramic industries maintain chemical laboratories. Control analysis and research are conducted now chiefly in connection with the manufacture of cement, glass, china and porcelain.

There is, however, a growing interest in the scientific aspects of the ceramic industries. The materials used are subject to end-

less variation and should be handled with an understanding of the chemistry and physics involved.

Because of the rapid development in the ceramic industries and the need for more scientific method five educational institutions in the United States have provided special training in ceramics, covering the physical and chemical principles of the production of silicate products—the winning and preparation of raw material, shaping, drying, burning and fusion, the composition and application of glazes, glasses, enamels and colors. Ceramic engineering includes thorough preparation in inorganic and physical chemistry, and in physics and mechanics.

Cement. In the production of cement the function of the chemist includes these general factors: the development of new products, the utilization of waste materials, the improvement of the quality of products already manufactured, the increasing of the efficiency of the plant. Trade associations in this field are striving to show the value of the chemist to the manufacturer. There is reason to expect a growing demand for chemists as the industry develops scientifically. Cement has come to be next to iron and steel the most important construction material.

Some questions which have been pointed out[1] for solution in this field are:

"Portland cement and gypsum. The addition of small amounts of gypsum to cement increases the setting time. It has been suggested that the Portland cement grains become coated with a film of gypsum; but Kuhl and Knothe[2] rule this explanation out on the ground that no such coating can possibly be formed either during grinding or on addition of water. Since gypsum is softer than clinker, it is probable that the gypsum particles are distinctly finer than the cement particles. The work of Fink[3] and of Briggs[4] proves that under these conditions the fine gypsum particles would coat the coarser cement particles. It is, therefore, a question of fact whether this happens or not, and the modern microscopist ought to be able to answer this question one way or the other.

"Lime and barium carbonate powders are said to stick to charcoal while calcium carbonate and barium sulfate do not. This should be confirmed or disproved and experiments should be made

[1] Wilder D. Bancroft, Research Problems in Colloid Chemistry; Reprint and Circular Series of the National Research Council, Number 13.
[2] "Die Chemie der Hydraulischen Bindermittel" 1915, p. 252.
[3] Journal of Physical Chemistry, **21** (1917), 32.
[4] Journal of Physical Chemistry, **22** (1918), 216.

to determine how far the chemical nature of the powders is a factor, and to formulate the laws."

There are assumed to be certain limitations for women in the laboratories of this industry. "Many cement plants are situated in out of the way places and do not offer many advantages to women employees. The plants operate 24 hours a day 7 days a week, and some chemists are necessarily on duty on night shifts. While sometimes certain chemists are employed for the day shift and others for the night shift, it often happens that they are rotated."

(*Chemist in a structural materials research laboratory.*)

One director of laboratories who feels that the chemical field as a vocation for women will present greater opportunities than ever before also considers that "there now are certain limitations, and some of these will continue to exist. The arrangement or location of the average works laboratory is not suitable for the employment of women chemists, particularly if the position calls for considerable mill work, which is usually the case.

"In large, well-equipped industrial research laboratories there are no good reasons why women trained in this work can not satisfactorily perform all the duties ordinarily undertaken. Research work that must later be followed through in a practical mill way, of course, is rather difficult for the average woman to handle, though oftentimes the mill development is assigned to others."

This last suggestion has been made in varying forms by other employers and may point the direction of future readjustments which will obviate in a measure the limitations of women.

Refractory Materials. With the increase in high-temperature processes there is great need for the production of more reliable refractory materials.

"There is a demand for better quality in refractories, the real urgency and volume of which are growing apace with the rapid development in more efficient manufacturing equipment. The most vital limiting factor in the development and adaptation of electric furnaces is adequate refractories, the present furnaces having many compromises in design and operations, and serious limitation in use because of failure of the refractories to withstand the service conditions that would otherwise be placed upon them. . . . New alloys that require higher temperatures for tempering, new glasses that necessitate more intense devices that entail more severe temperature changes, new by-products that must be reclaimed to make the essential process commercially feasible; all of these and many

more create an actual, not fanciful, demand for a refractory that will be superior to that which hitherto has been considered adequate. These new requirements and these changes in requirements call for a distinct applied chemical engineering, a specialty in ceramic engineering, which must be employed jointly by the producer and users of refractories." [1]

The manufacture of refractories is frequently combined with the manufacture of abrasive materials. Laboratories are maintained also by users of refractories, such as manufacturers of coke ovens, for the examination of refractory materials not only for their own construction work but also for the information of manufacturers and users of such materials.

The Refractories Manufacturers Association has a technical division with a central laboratory to which the refractories industry may turn for obtaining analyses on and advice respecting ceramic materials.

Glass. The manufacture of glass is safeguarded by the chemical analysis of all substances entering into it, including not only silicates—clays and rocks, but also mineral and vegetable oils, natural and artificial pigments, iron ores, lead, zinc, copper, steel and rare earths. Better control of the product as well as new methods of manufacture and new products depend upon further research.

"Comparatively little systematic work has been done on the relation between chemical composition and physical properties of glass. Such work will lead to control of strength, color and other qualities of glass, and will result in wide extension of the use of the material.

"As to the immediate problems for the chemist in the glass industry, the most urgent perhaps is to provide a suitable material for the container in which the glass is melted. The clay now used for this purpose dissolves in the glass and glass melting as at present carried out is like trying to melt ice in a container of sugar."

(*Vice-president of a glass company.*)

The recent development of high temperature resisting glass has made possible not only glass cooking utensils but also glass-enameled steel and iron equipment used in milk plants, in canning plants, in making pharmaceutical and chemical products. Technical control is essential; of prime importance is the quality and uniformity of the raw materials used.

[1] Ross C. Purdy, Superior Refractories, in Journal of Industrial and Engineering Chemistry, December, 1919.

"A failure to appreciate the possible variations of raw materials and the consequent results is a very serious matter. As an extreme case we know of a particular instance in which an enameler was using borax which had been stored in bags quite close to a furnace. The theoretical composition of borax and the composition which will be quite closely approached under normal storage conditions is approximately 53 per cent sodium tetraborate, the balance being water of crystallization. In the case noted the sodium tetraborate figure ran very close to 70 per cent. In other words, for every 100 pounds of borax taken, 70 pounds of sodium tetraborate were introduced rather than 53 pounds. At this particular time the enamel was running very soft and overburned very readily. The explanation is obvious.[1]

Research laboratories are also maintained by companies which manufacture glass-enameled steel for studying the possible uses of this product in industries in which it is not yet introduced.

In the laboratories of manufacturers of optical goods, chemists are engaged in work on glass making as well as on various other materials.

It is the opinion of the chief chemist in a window glass plant that the future demand for chemists and chemical engineers in the glass industry will increase on account of the comparatively small amount of research and technical work done at the present time by the average glass manufacturing concern.

In this industry again the work of women in chemistry has so far been limited to the laboratories.

A woman chemist in a glass company has found that "the woman can never go as far as the man because as yet she can not go out into the plant, which is the type of position the average industrial male chemist seeks."

Yet this same chemist considers her vocation "a growing field which will probably be entirely occupied by women in the years to come." The conclusions of another woman in this industry are that "there are certain tests and experiments in the industrial field that a woman is physically unable to do, but they are very few. There is one handicap still very prevalent. Women will rate themselves lower than men and until they realize that their brains are worth as much as a man's, who has had equal chance and training, their advancement will not come so rapidly."

[1] Emerson P. Poste, The Manufacture of Enamel Lined Apparatus, Journal of the American Ceramic Society, December, 1919.

China and Porcelain. This industry is one of recent development and as yet of limited extent in this country. Laboratories are, however, already maintained for control and research. "From the mining of the raw materials to the finished article we have positive laboratory control which insures uniformity of product," is the report of an industry producing chemical and scientific porcelain.

The chemist in charge of laboratories in a plant manufacturing china describes the present situation as follows:

"Until recently the research and control work done at potteries has been mostly by practical men in charge of plant operations. Now, however, there are a few potteries which have control and research laboratories in charge of trained men. This company belongs to that small but progressive group.

"So far as I know there are no women employed in the laboratories of any of the potteries. As yet our laboratory work has not progressed to a condition of high specialization. We require men of broad and thorough training, who are able to approach problems from many angles and to attack them with scientific understanding. Therefore a highly scientific type of mind is desirable, and for this reason I doubt if there will be much opportunity for the average trained woman chemist or physicist in this field for some years to come."

Chemical Products. The chemical industry produces many finished products, and many which are used only for making other substances. The acids made in one factory may be used in another to chlorinate, nitrate or acetate organic or inorganic materials. Salts made in one factory may be used to manufacture pigments in another. This industry is one of intermingling processes, one dependent upon the other.

Chemicals. There is no uniform agreement as to the classification of products under the general head of chemicals. The products listed by Drug and Chemical Markets under divisions which are "based upon industrial and trade use" are as follows:

Fine chemicals—medicinal, photographic, CP reagent acids and chemicals, except synthetic aromatics. (Approximately 300 are listed.)

Heavy chemicals—industrial and metallurgical acids and chemicals, except metals, dyestuffs, tanning materials and fertilizers. (About 150 are listed.)

Coal-Tar Products[1]—crudes and intermediates.

Oils—the fatty oils of animal, fish and vegetable origin.

Crude Drugs—the natural botanical products sold through the drug trade.

Essential Oils—including the oleoresins and the synthetic aromatic chemicals.

The products which are included in this general group in the classifications of the census of manufactures are as follows:

Chemicals

Acids—sulphuric, nitric, mixed, acetic, boric, citric, hydrofluoric, muriatic, oleic, phosphoric, stearic, tannic, fatty acids, miscellaneous.

Sodas—bicarbonate of soda, caustic soda, sal soda, including monohydrate crystals, soda ash, borax; sodium phosphate, silicate, sulphides, sulphate, bichromate, benzoate, sulphite.

Potash and Potassium Salts—crude potash, etc., potassium carbonate, potassium hydroxide.

Alums—aluminum sulphate, alum cake, concentrated alum, burnt alum, potash alum, soda alum.

Coal-Tar Products[1]—coal-tar distillery products, chemicals or medicinal preparations from coal-tar.

Cyanides—yellow prussiate of potash.

Bleaching Materials—hypochlorites, hydrogen peroxide, bisulphate of soda, lime, etc., chlorine.

Chemical Substances Produced by the Aid of Electricity—chlorates, hypochlorites, caustic soda, caustic potash, lye, ferro and other alloys, oxygen and hydrogen.

Plastics[2]—pyroxylin, including goods sold under trade names—celluloid, fiberloid, viscoloid, xylonite in partially manufactured form as rods, sheets, blocks, etc., finished goods—rubber substitutes, other plastics, including artificial silk.

Compressed or Liquefied Gases[3]—anhydrous ammonia, carbonic acid gas or carbon dioxide, laughing gas—nitrous oxide—oxygen, hydrogen, other gases—cyanogen, nitrogen and liquid air.

Fine Chemicals—alkaloids, amylacetate, chloroform, ether, gold salts, silver salts, platinum salts, thorium compounds (radium, uranium, vanadium), vanillin; chemically pure preparations in-

[1] See p. 92.
[2] See p. 66.
[3] See p. 111.

cluding acids, alcohol, etc.; chemicals used in the manufacture of photographic materials; other specified fine chemicals—refined camphor, synthetic oils and perfumery bases, refined fusel oil, hypophosphites, ethyl chloride, sulphon—methane—sulphon etyl-methane, nicotine, butric ether—named in order of value; chemicals made use of in analytical operations, in scientific research and in pharmacy; toxins and antitoxins.

Chemicals not Otherwise Specified—acetone, cream of tartar, epsom salts—magnesia sulphate—formaldehyde, glycerin, arsenate of lead, niter cake, ammonium salts, barium salts, copper salts.

All Other Products—chiefly by-products and residues.

The extent of this industry is significant from the point of view of the chemist since the processes involved are all chemical, require chemical control and depend upon trained chemists for development. The census figures are as follows:

	Number of establishments		Increase	Value of Product		% Increase
	1919	1914		1919	1914	
Chemicals in general	811	754	57	$603,555,400	$200,195,800	201.4
Sulphuric, nitric and mixed acids industry	39	32	7	31,470,500	15,215,500	106.8
Subsidiary Chemical products in other industries..	563	327	236	91,087,600	26,926,700	258.2

The actual number of wage-earners engaged in the manufacture of chemical products December, 1919, was 65,918, of whom 60,323 were men, 5,595 women. A large proportion of the great increase in this industry was due to war conditions; the production of chemicals which had been imported has been developed here. What the future will be will depend in large measure upon the ability to meet foreign competition. In any case the contribution of the chemist to more efficient production will play an important role in that future.[1]

Chemical products are manufactured in varying combinations by different companies. One firm may specialize in manufacturing

[1] See Harrison E. Howe, The Future of the American Chemical Industry. The Annalist, January 9, 1922.

oxalic acid and formic acid and also produce phosphoric acid and its salts, baking powder chemicals and epsom salts; others may manufacture primarily potassium bicarbonate, or muriatic and sulphuric acid; or there may be a great variety of products from one plant—caustic potash, formic acid, chloroform, zinc chloride, acetate soda, barium chloride, naphthalene, sodium cyanide, permanganate of potash, sal ammoniac, for example.

Caustics and chlorine products are produced by an electrolytic process; while the analyses in the control laboratory of raw materials and finished products do not require any knowledge of electrochemistry, any chemical work connected with plant processes does require such knowledge.

One of the important "fine" chemicals is alcohol. It has recently been predicted in the Scientific American that within a few years alcohol, or fuel with an alcohol base, will largely or entirely replace gasoline as a fuel for motor cars. Already its use as a solvent, as a raw material in the making of ether, mercury fulminate, chloroform, and many other drugs and chemicals, is extensive. The growing importance of alcohol brings to the front the problem of its cheap production. Various investigations are under way to develop to a commercial stage the production of alcohol from many materials from which it is theoretically possible to obtain it.

The subjects engaging the attention of research chemists in the manufacture of chemicals are suggested by a few brief summaries of the research subjects in various plants:

1. The improvement of the manufacturing process for sulphuric acid and the utilization of waste material.

2. The development of new outlets for chlorine, the betterment of present processes and the manufacture of small tonnage.

3. Problems involving the application or manufacture of silicate of soda, a study of its properties as an adhesive, as an ingredient of acid-proof cement, asbestos insulating material, coating materials for paper and wooden packages to prevent absorption of grease, as an agent in refining vegetable oils, etc.

4. Electrolytic processes, including electroplating, manufacture of sodium cyanide, manufacture of peroxides and persalts, bleaching and finishing of textiles, chlorination of organic compounds, manufacturing formaldehyde, etc.

In plants producing chemical products women have to some extent been employed in analytical laboratories and also for research work. They have been found "careful and neat," "trustworthy and conscientious"; their work has been compared very favorably with

that of men in analysis, a little less so in research. An "undetermined but good" future is held out to them in one plant in which women chemists have been employed for 10 or 12 years.

Another company finds, because of its administrative plans, limitations to the promotion of women:

"Women as chemical analysts gave us excellent service, in some cases being superior to men.

"The reason we are not employing women in our laboratories at the present time is primarily that we use the laboratory as a training point for sizing up and culling out material destined for ultimate use in the plant in the capacity of foremen, etc. In an inorganic chemical plant this is hardly work to which women could aspire." *(Head of research department in a company manufacturing chemicals and dyestuffs.)*

In the manufacture of "heavy chemicals" the general attitude of employers toward the employment of women chemists is one at least of doubt if not of negative discrimination.

"It is quite possible that in the future we may have opportunities for women chemists who could be used only on analytical work in the laboratory. The nature of our business is such that it is generally most advantageous to employ men chemists because we can use them on outside work as occasion requires, and, depending upon their ability and other qualifications, they can be promoted from laboratory work to work of greater responsibilities."

(General manager in a company of manufacturing chemists.)

The possibility of adjustments in organization to meet the entrance of women chemists into industry is suggested by one chief chemist:

"We have had girls in the laboratory as analysts and they worked out well enough, but they were limited in their usefulness by the fact that they could not be expected to get out into the dirt of the plant to collect samples, etc. We had practically no routine indoor work. Most of the chemists at present holding good positions have had to work up through a plant experience impossible for women under the old system, but one can foresee the day when such a system will be developed as to permit women to enter on this field."

Several firms which have employed one or two women in the analytical laboratory for some years report favorably upon their work. Plants in which women were taken on during the war stringency report variously: in one plant five out of six women who did satisfactory work in plant control analysis and experimental pro-

cesses were released to permit service men to return. In another plant women have been retained to make up the entire staff of analysts in the control laboratory and may be included on the research staff, so satisfactory has been their work. In a third plant which employed four women no women have been retained in the laboratory but one has been transferred to the position of filing clerk and assistant to the librarian. The reasons for releasing women from this laboratory were summarized as follows:

"1. Our work is of such a nature that we employ chemists on shift in the plants. Women can not take the place of such men as they are not so flexible.

2. It was necessary to reduce our laboratory force.

3. We wished to make room for returned service men.

4. The women could not do the volume or quality of work which we required. They were not satisfactory as analysts. . . . This can be qualified by stating that two of the four began to develop into good analysts after a year's service."

(Acting laboratory manager in a company manufacturing alkali.)

One of these four women had only a short training in pharmacy, which may indicate one important reason for the unsatisfactory results recorded above.

"The greatest limitation of women, however, in a laboratory like ours, where the research problems are mainly connected with industrial processes in the plants, is the fact that women chemists are necessarily confined to the laboratory and can not conduct plant investigations like men. In order to achieve the best results in commercial research, it is generally necessary that the chemists have a thorough acquaintance with the problems being studied from the plant side, and this, of course, can only be gained by considerable plant experience. I would say that this is the strongest inherent limitation for the woman chemist in the industrial field."

(Assistant chief chemist in company cited above.)

The experiences of a few of the women chemists in this field of industry are as follows:

One chemist outlines her work as research on the synthesis of new compounds, and on methods of producing old ones more economically and efficiently, working out the processes to be taken to the factory, working out research problems for customers. Physical chemistry, quantitative analysis and organic chemistry she has found of greatest assistance in her special work.

One woman who has had considerable opportunity to do plant work is worthy of note since such opportunity has been rare. She has "had to deal with labor of all kinds, mostly ignorant, many foreigners among them," and all of them considered her "boss" as far as the laboratory was concerned.

In one large chemical plant a woman has had general supervision of the plant laboratory, in which raw materials, manufactured products and manufacturing processes are controlled. Her comment on plant work is that women have not the *training* for it and therefore in few cases could become plant superintendents; her conviction is that since it is rather a new field the opportunities must be made by the individual.

Another woman chemist comments: "From my experience I think women are as well paid as men for the same kind of work, but men have rather more initiative to work themselves up, due partly, I suppose, to the fact that the profession is so new to women."

Various groups of industries are so closely allied with the production of "chemicals" that they may well be grouped under chemical products; among these are biological supplies, fertilizers and pharmaceutical products.

Biological Supplies. In the production of smallpox and various bacterial vaccines, antitoxins and other immune serums, glandular products and similar biological supplies, the larger proportion of scientifically trained workers must be bacteriologists. There is, however, also a need for physiological chemists and they are employed in every important plant producing such biological products.

It is an industry which is not extensive, but one whose products are in steady demand and in which the need for scientifically trained workers is constant.

Women are holding excellent positions in this field. Among the duties that have been performed by them are: scientific supervision of filling and finishing products, assisting physicians in research work, standardization of serums, manufacture of bacterial vaccines, assisting in the chemical laboratory.

In one important plant women are considered "even more satisfactory in this work than men, because they are peculiarly adapted to it. Although more women leave for reasons that do not take men away, more men leave because of the detail character of the work."

Fertilizers. The census of manufactures reports a decrease in the number of establishments producing fertilizers in the five years

from 1914 to 1919, from 784 to 599. The value of the product increased so greatly, however, as to suggest no corresponding decrease in quantity of product. This value in 1914 was $153,196,000, while in 1919 it had grown to $278,610,000.

Nitrogen, potassium and phosphorus are the three of the thirteen "elements" necessary for crops, whose supply in ordinary soils needs to be supplemented in order to secure satisfactory production. A beginning has been made in the manufacture of nitrogen, for the supply of which we had depended upon importation, and which was used up in such reckless quantity for explosives during the war. So far the chief industrial source of nitrogen has been the coke-ovens. It is only in recent years that this most important by-product has been saved.

The fixation of nitrogen from the air is a well-developed industry in Germany but a new business in this country. It began a rapid development during the war which has been halted, but very probably only temporarily.

Phosphates are produced in this country in quantity sufficient for large exportations. The question of an independent supply of cheap potash is an unsolved one challenging us today. Fertilizers are also manufactured in which all three of these elements appear in proper proportion for plant needs.

Recent experiments with carbon fertilization have indicated the possibility of increases in production through hitherto unused fertilizers.

Fertilizer materials as listed in the Drug and Chemical Markets include ammonium sulphate, dried blood, ground bone, cyanamide, fish scrap, nitrate soda, tankage, phosphate rock, potassium muriate, potassium sulphate. The products are analyzed by the census into complete and ammoniated fertilizers, concentrated phosphates, superphosphates, and other fertilizers.

Much of the experimental work in the chemistry of soils and fertilizers is carried on in the United States Department of Agriculture and especially in the laboratories of agricultural experiment stations.[1]

A chief chemist, in a manufacturing plant producing fertilizers, writes in regard to the scientific aspects of the industry:

"In regard to the problems instant to fertilizers, I will say that there are quite a number which need considerable study.

"One of the most important is the cause of the hardening of acid phosphate and of mixed fertilizers and a means of prevention. Acid phosphates after they are made and bagged frequently get very

[1] See p. 178.

hard and difficult to handle and so do mixed fertilizers which cause the manufacturer much trouble. The exact reaction which takes place in the manufacture of acid phosphate immediately and on standing is another interesting question. A scientific study of the neutral and alkaline permanganate methods of determining the availability of nitrogen also needs scientific study.

"These are some of the most important questions, while of course numerous others come up from time to time.

"I think the demand for chemists in the fertilizer field will increase and there will always be a steady demand in this field and, as time goes on, I think that demand will decidedly be increased.

"There are no inherent reasons why women should not make excellent chemists for fertilizer companies. It is largely a question of the preference of the various companies and of the men in charge."

Women have entered this industry also as analytical chemists. The chief technologist of one large company discusses their work as follows:

"In the field of nitrogen fixation this company has been using women as analytical chemists in two of its plant laboratories, and, so far as I am informed, with complete success. In both cases the work was of the nature of plant control, somewhat routine in character, and these chemists seem to possess sufficient technical training to meet the requirements, although I am of the opinion that they were not graduates of the more highly developed institutions.

"In the particular field of activity covered by this company there is great room for research on the production, qualities and properties of an almost infinite number of nitrogen compounds of complex organic nature. Any and all of this research work could very easily be taken care of by trained women chemists of superior education. In fact, from my own experience I believe a great deal of the successful research work of this sort seems to come largely as a matter of intuition, and if my own personal experience is borne out in general, then the women chemists should be particularly adapted to this class of organic research.

"As a matter of fact research seems to be about half intuition and the other half skill and experience. To be successful in the field requires first, a careful preparation, which means four or five years of intensive study in an educational institution of high standing, followed, if possible, by a year or two of teaching, and then innumerable years of actual contact and experience in the laboratory. The number of women willing to apply themselves to this

rigorous training, and at the close of the same to devote themselves to this field of activity over a long period of years seems to be limited. Most of them change their vocation before they have well started on the long road. It might be of considerable service to point out to the chemical student that if chemistry is merely to be made a stepping stone to some other vocation at a comparatively young stage of the chemist's life, then chemistry is not the vocation to be chosen. The first few years after leaving the educational institution of the average chemist's life are spent in routine work, which is neither very remunerative nor is it of particular interest. I think too much emphasis can not be placed upon the fact that the student of chemistry wants to go into it with a full knowledge of the fact that many years must be devoted to the subject before constructive work can be accomplished."

Pharmaceutical Products. The classification is not sharply defined as between fine chemicals and pharmaceutical products; the latter are those used for medicinal and food purposes and would include the products listed in the United States Pharmacopœia. Manufacturers of pharmaceutical products employ chemists and also bacteriologists and biologists in their laboratories. From an important plant in this field comes the statement that the manufacture of medicinal or pharmaceutical preparations is now firmly established on the basis of exact chemical control and chemical research, that the laboratories in the industry will continue to be enlarged, and that the number of chemists, pharmacologists and bacteriologists will increase.

The chemist in the pharmaceutical manufacturing laboratory is confronted with a multitude of problems; as suggestive of their variety the following examples have been cited:

1. Potassium Iodide—determination of the cause of its instability and the conditions which lead to the development of iodate.

2. Chemical reactions involved in the production of discoloration in elixirs containing acids, also those containing iron salts.

3. Determinations of the value of various preservatives in pharmaceutical preparations, and the determination of the conditions under which these several preservatives can best be employed.

4. The discovery of better emulsifying agents and the proper elucidation of the basic principles underlying the manufacture of medicinal emulsions. (This involves a very thorough knowledge of colloidal chemistry.)

5. Improved processes for determination of active principles

such as alkaloids, fixed oils, essential oils, glucosides, etc., in drug extracts and tinctures.

6. Determination of the therapeutically active substance in amarga, digitalis, convallaria, and others.

7. Separation and determination of chemical constitution of vitamines, of pepsin, of rennin.

8. Separation and determination of chemical constitution of the active substances in thymus gland, pineal gland, parathyroid gland, liver, ovaries, placenta.

9. Constitution of the proteins.

10. Modification of the various well-known alkaloids so as to develop new therapeutic or physiologic activity.

11. Production of new synthetic narcotics and anæsthetics.

12. Discovery of synthetic remedies used in the treatment of various diseases due to the spirochetes, such as malaria, sleeping sickness, syphilis, etc.

It is evident that the whole range of physiological chemistry is of importance to the manufacturer of pharmaceutical products.

Women have been employed in this industry as analytical and research chemists, and in smaller plants as assistant to the superintendent and as chief chemist directing the manufacturing process. Several companies which have no experience with women chemists are open-minded as to employing them: "We have not at the present time any women chemists in our employ, not that we have any objection to employing them, but simply because we have not had any applications from women who had fitted themselves to do such work as our laboratory calls for."

(*Manufacturers, importers and exporters of drugs and chemicals.*)

"I may state that women could be employed as assistant chemists and the salary would depend altogether upon the training that they had, and that they would be rated the same as men. . . . The sex of a person would be no drawback in securing a position at our plant." (*Chief chemist in a pharmacal company.*)

"In the pharmaceutical field we will say that there does not appear to be any inherent limitation for women chemists excepting perhaps that when a woman goes into a commercial chemical laboratory she is doing pioneer work and is perhaps confronted with conditions and handicaps which always form a problem for pioneer workers." (*Makers of fine pharmaceuticals.*)

Comments of employers in this field who have experience with

women chemists indicate that the obstacles to their success lie in lack of adaptation to practical plant work and in the likelihood of their instability as workers. A firm which has been employing women in the analytic department and on formula work for fifteen years finds them strong in detail, but weak generally in the comprehension of business principles and as executives, and therefore prefers to employ men for practical and experimental work.

The comment of an employer who took on women as chemists during the war, retaining one afterwards, is: "Work is very satisfactory; consider them superior to men in some respects; reports are more detailed," but adds, "A woman chemist would probably not be chosen to take charge of departments (that is, certain manufacturing departments). She would have no future that I can see except increase in salary."

A third testimony is as follows: "We employ both men and women chemists, and have no prejudice against employing them. We have five women at present on our staff. We find that while their technique is generally satisfactory or can be made so, they are inferior to men in interpretation of results, that is to say in matters of judgment. They are apt also to show less initiative in research and are less fitted for sending into the factory to adapt laboratory formulæ to factory practice. All generalizations are dangerous and the above have their exceptions, but in the main they represent our present impressions."

(*Assistant chief chemist in a drug company.*)

In a plant in which a woman chemist was first taken on during the war and in which five were employed, one in research entirely, at the end of 1919, it was found that they worked more slowly but more carefully than men but showed less initiative. Research chemist and manager of analysis are the positions to which women may look forward here.

One more employer may be cited, who emphasizes the consideration of the instability of women as workers:

"Of course, there is no use in laying any particular stress upon the single inherent limitation which women chemists labor under in common with all women, and that is the tendency or likelihood to marry, which necessarily removes them from the active field of professional work sooner or later, or to a greater or less degree.

"As threadbare as this argument is, I have found it the one most serious objection to the employment of women as chemists, for it is in the field of chemistry peculiarly where the well-prepared person steadily increases in value through the passing of years and the gaining of experience."

Women chemists in the pharmaceutical industry recognize similar limitations. "Lack of initiative in the individual and a desire on the part of the manufacturer to have chemists who can go through the plants. They hesitate to employ women in positions requiring that." This comment is from an analytical chemist who thinks chemistry extremely desirable as a vocation for women if they are equipped for it.

An analyst in a control department who thinks chemistry a very good vocation and who is glad to have chosen it as hers, feels the chief limitations lie in the lack of knowledge of engineering, but is sure there is always room at the top of the ladder even for women and that advancement depends upon the individual. She recognizes that "many men are apt to be skeptical of women's ability in this field. As is apt to be the case in any profession where women are comparatively new, they must work twice as hard as the neighboring man. On the whole salaries are equal for equal work."

A woman whose duties have included direction of shop work and unskilled labor feels the need of engineering, of studying plant efficiency, accounting and some law. "A woman must always keep in mind that a manufacturing house is a business and therefore yields and costs play an important part in the system."

"Finally, the woman chemist in a smaller plant, whose work includes the analysis of incoming crude bases for medicines, such as parts of plants, salts, minerals, solvents; analyses of the per cent of potent ingredients in finished products, such as pills, extracts, syrups, tablets and all U-S-P drugs; the solution of such factory and laboratory problems as arise and the effort to simplify manufacturing processes, considers chemistry a splendid vocation for women who are suited for it, with no limitations for a woman of ability and will power who applies herself to her vocation. She finds that few women are as yet able to fill the positions of responsibility.

Closely allied to the manufacture of strictly pharmaceutical products is the production of specialties for druggists, such as toilet preparations. In one plant in which are manufactured cold cream, salve and tooth paste, a woman, as chief chemist, has worked out the formulæ for various products and supervises the plant operation.

Coal and its Products. It is only in recent years that this country has become aroused to recognize the waste and reckless squandering of resources in the burning of raw coal. It has been estimated that for each ton of soft coal burned, by-products at

market prices (September, 1921) to the value of $4.50 are absolutely wasted. In the development of great industries out of this waste the chemist is playing the leading part.

One of the most rapid industrial developments of the last few years has been in the construction of synthetic organic chemicals derived from the tar products which are a residue of the distillation of coal. The use of coke and gas, made by such distillation or carbonization, is rapidly increasing and their by-products, ammonia, tar and its products, have immense value in the chemical industries.

Because of the interest in the recovery of by-products, both producers and consumers of coal are finding it expedient to have tests made of the value of coal for treatment in by-product ovens, yield of ammonia, gas, tar, benzene, toluene and other by-products, the quality of coke obtainable and other points of information necessary for the sale or proper utilization of the material.

The coal industry of the United States has only recently reached a point where the washing of coal has become a matter of any importance. With enormous fields of very high grades of coal, it has been easier to mine and use the coals which required the least preparation, rather than to mine low-grade coals which required a great deal of cleaning. The development of the by-product coke industry has placed a greater demand on the coal fields and as a result it is becoming more and more profitable to wash coals with high ash and sulphur content which are otherwise well adapted for coking.

Coal tests are made at the mines, in industries producing their own coke and gas, in plants manufacturing coke ovens, and in coke and gas producing plants.

It is only the larger coal companies in the country which employ chemists. It is the general custom rather to send samples for analysis to commercial laboratories.

Coke. The census of manufactures reports 253 establishments producing coke in 1919 as against 231 in 1914. The value of the product has increased from $99,275,000 in 1914 to $299,879,000 in 1919.

Companies manufacturing ovens for producing coke provide laboratory service for their customers as well as for the control and development of their own manufacturing processes. One such company offers, for example, twelve kinds of tests for coal, eleven for coke. Coke is classified as furnace, foundry or domestic, depending upon its chemical and physical properties.

Women chemists have been employed in laboratories for analyzing coal and coke. Two of these women have described their work as covering so wide a range as to minimize the routine. Although the primary analysis is that of coal and coke, cements, oils, tars, etc. are also to be analyzed. One woman chemist summarizes her situation as follows:

"My own laboratory work is chiefly analysis of coals and cokes, but I have also to oversee a quantitative laboratory where an infinite variety of analytical problems comes up. . . . I have been on an equal footing and have advanced more than some of the men workers in the same place. . . . There is almost unlimited opportunity for advancement. . . . I believe that at present it would be difficult for a woman to go out into a plant. . . . I believe there is a prejudice still existing against taking women for research work. In some sense, I believe it to be justified by the general attitude of mind of women. This is disappearing, however, opportunities are increasing, and I believe it possible and probable, that women will be admitted to an equal standing in research as they are now in other lines."

Carbon Products. Carbon derived from coke is made into form for dry batteries, storage batteries, carbons for electric arc lights, and for use in electrolysis, carbon brushes for generators and motors, etc. Graphite, the harder form of carbon, is made available in quantity by the electric furnace; it is extensively used for crucibles and electrodes, dry-cell filler, paint pigment, stove polish, pencils, tubes, muffles, graphite and grease lubricants. The census of manufactures reports 24 firms engaged in the production of graphite in 1919 whereas there were but 11 in 1914.

Another carbon product of the electrical furnace is calcium carbide, used in nitrogen fixation and as the basis for producing acetylene gas, with its further compounds, alcohol, acetic acid, acetone and isoprene, the mother substance of India rubber.

Chemists are in charge of the manufacturing processes and are carrying on development and research work on the chemical and electrochemical problems related to these products.

A carbon plant which has been employing women for some years, prior to and not in connection with any conditions brought about by the war, makes no discriminations whatever on account of sex and has taken pains to have all the facilities of the laboratory and working conditions equally pleasant and satisfactory to both sexes.

In the manufacture of graphite the tests are chiefly physical

rather than chemical; the chemical analysis is mainly concerned with the lubricant by-products. This analysis has been deemed suitable work for women; any one such analytical job is varied rather than routine. Research in this industry "involves climbing over electric furnaces and handling heavy materials"; it has not seemed suitable for women.

A plant producing acetylene, storage batteries, etc., which took on several women chemists during the war for chemical research work, has retained them. They are considered "mentally just as competent as men, physically slightly less competent"; they may hope for any future advancement that may be expected by the men.

One of these women has been placed in charge of chemical control. She has taken a master's degree in chemistry, but advises a chemical engineering course in a recognized university as the best preparation for work like hers. She describes her duties as including the responsibility for all analytical work, largely inspection and analysis of raw materials, the plant control of chemical processes, and research of a chemical nature on storage batteries.

Her conviction is that "prejudice on the part of employers is decreasing and women may make of their positions success or failure as they will. Factory life has no 'feminine' attractions, one must make interest in the work itself compensate. With equal ability and training for the position, chances are equal. Most women lack some qualifications of training or ability that a competing man possesses. Women as a rule make better routine workers than men and poorer research workers. They lack initiative but have accuracy in details which few men exhibit. However, if a woman is adapted to independent research work there is equal opportunity with men."

Gas. According to the census of manufactures the number of establishments producing illuminating and heating gas decreased from 1284 in 1914 to 1020 in 1919, although the value of the output was $328,851,000 in 1919 as against $220,238,000 in 1914.

The purification of the gas is one of the great problems of this industry. A chief chemist foresees the probability that gas companies will gradually develop into huge plants where intermediate products will be extracted from the valuable by-products made in the manufacture of gas. This will mean both more chemists and a greater amount of research work.

"The only limitation for women chemists in the gas industry is the large amount of plant work which a gas chemist must perform. This would not be suitable for a woman chemist. There is, how-

ever, considerable laboratory work to be done in the gas industry which a woman chemist could handle, and I think you will be interested to know that I have a young lady working in the laboratory who takes care of all the coal and coke analysis.

"The outlook in chemistry as a vocation for women for laboratory work, in my opinion, is very encouraging."

(*Chief chemist in a gas company.*)

Tar Products. In the rapid development of the coal-tar industries in the United States in the last few years research has played an enormous part. The United States Tariff Commission found that in these industries 11.5 per cent of all the employees are "chemists and technically trained men," and that the total expenditures for research work from 1917 to 1920 inclusive was in excess of $15,000,000.[1]

"A continuation of extensive research is necessary for the establishment of a competitive industry in the United States. It is a regrettable fact that there has been a tendency during the recent months to curtail research work. By following this policy manufacturers are endangering the future progress and in fact the very life of the domestic industry."[2]

It is a mistake to presume that many by-products are obtained directly from the tar or coal residues. Practically every process involves from five to eight or ten distinct chemical reactions and physical tests. These are each complex operations which require skillful manipulation and chemically correct conditions.

Only a very small proportion of the constituents of coal tar is used as a starting point in the dyestuff and organic chemical industries. Many of these compounds can be separated from the oils in relatively pure condition but the chemistry of only a few has been developed toward finding commercial uses. There are many more products still to come, all dependent upon the chemist. New possibilities are indeed unlimited.

The "crudes," the basic material for the coal-tar industry, are produced at by-product coke ovens, at coal-gas, water-gas and oil-gas plants. There has been a steady increase in the output of coal-tar by American coke ovens so that the demands of the domestic coal-tar chemical industry for crude materials is fully met.

From these "crudes" 236 "intermediates" were manufactured in 1920, by 119 firms.

"The increased variety and output of intermediates in 1920

[1] Census of Dyes and Coal-Tar Chemicals, 1920.

[2] C. R. DeLong, Present Status of Domestic Coal Tar Products Industry. Paint and Drug Reporter. September 12, 1921.

represents encouraging progress toward supplying the domestic needs for the manufacture of dyes as represented by the pre-war consumption in this country.

"For the development of a completely balanced and self-sustaining dye industry in this country, an increased output of certain intermediates already manufactured in small quantities, together with the production of other intermediates required in relatively small amounts, will be necessary. A color may frequently be used in small amounts only and yet be essential in the production of a given line of fabrics. Certain specialties in this class are not yet developed in the United States." [1]

Two coal-tar products have been developed as substitutes for camphor in the manufacture of pyroxylin plastics. These are classed as intermediates although used as finished products. This development is an important one as it offers a means of overcoming to some degree the monopoly which Japan has held in the past in the production of camphor.

There is great variety among the finished products of the coal-tar chemical industry. Many products are used as perfumes and flavors; "color lakes" are pigments adapted for use in prints, lithographic inks and many other purposes, by fixing a coal-tar dye on an inert base material such as aluminum hydroxide or barium sulphate; a number of coal-tar chemicals are used as photographic developers; synthetic tanning materials are of recent development; explosives and poison gases were highly developed during the war period.

The technical skill and research required in the manufacture of the present variety of coal-tar medicinals have been rewarded with notable accomplishments. The leading coal-tar medicinal in quantity is aspirin, the second acetanilide. From a medicinal standpoint salvarsan may be considered the most important coal-tar product in this group. Approximately fifteen new medicinal products were reported in 1920.

The coal-tar resin industry is a distinctly American discovery and development, and has resulted only from the most careful research and engineering skill. These resins are now made by four companies. They are of especial importance as electrical insulating materials and in the manufacture of varnishes and lacquers. They are used as synthetic amber, as enamels, as hard rubber substitutes, and synthetic wax in electrical condensers and in rubber manufacture. A large variety of products are made from these resins—valves and fixtures, vat linings, fume-proof coatings, disc

[1] Census of Dyes and Coal-Tar Chemicals, 1920.

records, printing plates, telephone receivers, brush backs, handles, and many others.

Important as all these products are, they are nevertheless subsidiary in comparison with the great dye industry. The output of dyes in recent years has reached approximately 85 per cent of the total quantity of finished products and may be regarded as the backbone of the coal-tar products industry. In 1797 the first prize was offered by a learned society for an American permanent dye. In 1920, 360 different dyes were produced. The number of firms manufacturing this output was 82; the total amount, 88,263,776 pounds, valued at $95,613,749, was equal to 120 per cent of the domestic consumption.

A close relationship exists in the manufacture of all these varied products and they are produced in varying combinations by different firms.

In the rapid development of the tar-products industries women chemists have had some new opportunities for securing industrial positions. The reported experience of two large companies may be briefly outlined:

1. Before 1917 this company had employed very few women chemists, the reason being that as a general rule its laboratories had been merely stepping stones in the young chemists' education. It had been the usual procedure to start all new technical men in the laboratories, placing them in outside work such as the supervising of chemical operations, as opportunity arose. It had always been thought impracticable to employ women for this purpose, since it would be rather difficult to place women in charge of many of the plant operations.

"This line of reasoning, however, does not strictly apply to this company's research laboratories, which are fairly large organizations in themselves, and we believe that the chances for advancement for women chemists are much greater along the lines of research work than in any other direction," was the comment of the head of the chemical department. At that time this company employed "quite a few" women chemists for routine analysis, as librarians, and for bibliographical work. It was felt that they lacked adequate chemical training as compared with men graduating from a "respectable" institution.

By 1920 eight women remained, only one of whom was doing really chemical work—analytical chemistry in the dye research laboratory. One had been transferred to the miscellaneous manufacturing department, the others held positions as chemical storekeeper in the experimental station, chemical secretary in the research

laboratory, editor and assistant editor of an abstract bulletin, translator, and worker on dyes patents.

The chemist in charge of the laboratories in which the largest number of women was employed during the war believes that the field for women in chemical industry is limited to their employment for some forms of laboratory work, for library work (that is abstracting, filing, etc.), and for statistical work; that, except in rare instances, where a large number of women are employed in actual plant operations and where it might be of benefit to employ an exceptionally well-trained woman executive to handle the woman labor either in a position of supervisor or assistant superintendent, there is no opportunity for the employment of women in actual plant operations; and that few employers will give women an opportunity to become thoroughly grounded in a subject through research, when it may be possible that, at the moment when advantage can be taken of the fruits of such research work, the investigator, by marriage, ends her career in the field of chemical industry.

He observed also in his experience with this small group of women that they were more sensitive on questions of family ties than men, and less willing to accept positions that would take them any distance from home; that men apparently have a better developed sense of business morality than women when judged by their willingness to live up to obligations which they accept; that women are apt to desire preferential treatment; that women do not stand the strain of hard continuous routine in the laboratory as well as men.

2. In 1917 a representative of a second company wrote: "To date, I have consistently refused to add women chemists to my staff, the reason being that my research organization is in the process of being formed and the research men must go into the plant and manipulate all sorts of plant apparatus, direct foreign labor of every sort, etc. You can readily see that a woman would be at a great disadvantage in this work. However, we are seriously considering the addition of women to our analytical staff, even though we feel as a whole the best place for a woman is not here. Later we may find that we shall need the characteristics peculiar to a woman chemist for our research work."

Two years later this company employed a number of women chemists in its various factory laboratories, including several in the research department and the assistant director of manufacture had concluded that "there is undoubtedly a very promising field for them in our business and, while they could not advance to positions of an executive character, it would be possible for the higher grade,

those having doctors' degrees, to advance to a salary of as much as $3,000 a year." The chief chemist commented on the work of these women that "as far as the laboratory work is concerned their work is satisfactory but, of course, it is impossible to have women develop the work in the plant."

Lack of experience and inadequate training were inevitable hindrances to the fullest success of women in these laboratories since, as has been pointed out, few were ready for the unusual emergency opportunities that were suddenly opened to them. Some employers have understood this. In one plant in which twelve women had been employed for analytical work and only one retained the chief chemist reported: "The work of women compared with that of men only fairly well in our case, as most of the women were not chemists but had taken a college course with only enough chemistry to fit them for routine work. I should say graduate women *chemists* compare quite well. The chief fault that I have found with women chemists is their lack of self-reliance. I should say it was timidity chiefly that makes them doubt their own work. This is a serious handicap and, I believe, will be overcome with a broader experience."

From one plant, in which women are employed as "junior chemists" in the control and research laboratories, the chief chemist reports:

"Most of the girls that we have had have shown more than average ability in comparison with the men chemists employed at the same time they were employed and doing the same kind of work, and have shown remarkable energy in the performance of their work.

"The future of women chemists in our employ is limited only by their training, character, ability and physical limitations. They should be able to advance to positions of senior chemists in both the research and control laboratories in so far as the research and control do not require them to take the results of their work into the plant.

"The salaries paid to women chemists will depend upon their individual values to the company and will be the same as that paid to men in similar positions."

The women chemists themselves who have worked in the laboratories of the coal-tar products industry present on the whole an encouraging report, even though they recognize all legitimate limitations, as may be seen from the following records:

"I have but one man over me and as his assistant, I am the

executive office supervisor of the dyestuff technical laboratory and have charge of all dealings with the chemical department such as deciding what dyes they shall go ahead to investigate and in what quantities, and keep track of their work in order to see whether they produce these dyes economically enough for us to market them. In a way I am the link between the research, the manufacturing and the selling of the dyestuffs. Incidentally I look after our advertising and supervise it, not only for circulars, etc., but also in some cases for exhibits; and answer a great deal of the correspondence of a technical nature that comes to us. . . . The dyestuff industry is so new that each one of us is putting in extra time in our desire to push it. The company does not demand this intensity, it is our own enthusiasm.

"Men have the better chance. I am glad to say that at present they are not started out at higher salaries but because women drop off into homes they are always newer and moreover an employer always has this in mind so that he is more apt to push a man than a woman, although he does not mean to be at all unfair. . . . The girl who goes in for chemistry must start her work and continue as if it were going to be a life job. For many it will not be, but all the while they are at it they must work as if it were."

One woman who started out as routine analyst was given charge, when a new plant was opened, of the control work on a new product where she was in charge of four men. It was her duty to see that the right samples were sent in from the factory and that all tests were made quickly.

An assistant research chemist, who is working on the determination of the constitution of various dyes, recognizes that chances for advancement in salary and opportunity are limited for women generally to laboratory work; nevertheless she esteems chemistry a satisfactory vocation. As to plant operation, her conviction is that the reason that women cannot take charge of it is mainly the prejudice of men against women doing such work.

A second chemist in the research department who started in analytical work concurs with this: "As one way of advancement men go out into the plant as plant chemists. At present most executives think this is not feasible for women, but I do not believe this attitude will always be held." This chemist finds that if ability is shown, there is good opportunity for advancement in position and that salaries are higher and advancement more certain than in most lines of work open to women, that chemistry as a vocation offers an excellent opportunity for those of initiative and determination;

not only because of the increasing importance of the chemical industry as a whole, but because the employer's attitude toward them is becoming more favorable as more women are being tried and found capable.

"Personally I have never been disappointed in chemistry as a vocation. It is an ever-broadening field, bound to require the services of a great many women. It is fascinating, instructive, pleasant work. The possibilities are what the women make them. Make your work the most vital thing there is—wholeheartedly—not as a temporary occupation between college and matrimony. Accept all the conditions men accept if you accept a man's job."

Corn Products. Altogether more than a hundred commercial products are now made from corn, largely due to the chemist's economy. The following table taken from an advertising circular of a manufacturer shows in a concise way how the different parts of the corn kernel are utilized:

Parts of Corn Kernel	Composition	Products
1—Germ	Oil and Oil Cake	Corn Oil, Corn Oil Cake, Corn Oil Meal.
2—Endosperm (Body of the Corn)	Starch	Dry Starches, Dextrines, and, by conversion, Corn Syrups (glucose) and Sugars.
	Gluten	Gluten Feed.
3—Hull	Bran	Gluten Feed.
4—Water added for Steeping	Soluble Substances of Corn	Gluten Feed.

The oil is used principally for soap and for making vulcanized products used for rubber substitute. The oil cake and meal from the cake are used as cattle feed. The glutten and bran, mixed with the soluble matters extracted by the water, are made into "gluten feed" also for cattle. All these are valuable by-products for which there is a good market. The starch is the raw material for making the various goods which are sold under the names of "glucose" ("corn syrup"); "corn sugar" ("grape sugar"); "dextrins," true adhesives which are usually made by roasting starch, besides numerous "dry starches" used by laundries, confectioners, and in many other industries as well as for household purposes.

The American Manufacturers' Association of Products from Corn includes ten companies in its membership.

The census of manufactures reports 56 establishments engaged in the production of glucose and starch in 1919.

Foodstuffs. This field is one which has long been deemed primarily woman's sphere. Women are making important scientific contributions to our understanding of foods and nutrition,[1] and to food control and research in government laboratories.[2] Yet in the manufacture of foods—baked products, canned goods, milk products, meats, etc., women are today playing a much smaller role than did their grandmothers who directly supervised the preparation of all food products. Large numbers of women operatives are employed in food industries, but as yet the scientific control and management are only in occasional instances in the hands of women.

Manufacturers of foodstuffs are under the necessity of providing scientific control of their products to insure that they meet the requirements of the federal pure food and drugs law. In growing numbers such industries go further and establish laboratories for research and development as well as for control.

Baked Products. The census of manufactures shows the large number of 25,232 establishments engaged in producing bread and other bakery products. The number has decreased slightly from the 25,963 establishments of 1914 while the value of the product has increased from $491,893,000 to $1,406,145,000.

In the bread baking industry there is considerable evidence of a changing attitude in favor of scientific control of raw materials and of production methods. There is a growing demand for scientifically trained persons as executive managers of bakeries. Organic chemistry, particularly biochemistry, with bacteriology as an important correlative, is essential in this industry.

The laboratories of the American Bakers' Association are occupied with the study of many matters of fundamental interest to the baker, such as flour types, with a view to obtaining the basic facts which determine the quality of flour; the control of fermentation; the problem of mold as it affects the baker. The director of these laboratories considers that "there is a good field for women in the laboratory end of the baking industry. Several women are already occupying excellent positions in connection with large baking concerns. There does not seem to be an opening for trained women in the operating end of the larger plants, although women

[1] See pp. 4, 17, 22.
[2] See p. 168 ff.

workers are now commonly employed in many branches of the baking industry. The biological end of the baking industry is still to be developed, and in this particular field women should find a fine opportunity."

A woman chemist in a baking company estimates that there are now only probably a dozen bakeries which maintain laboratories, but that the future promises a brighter outlook.

The operating department of a biscuit manufacturing company reports: "We take our chemists and put them through the factories for a practical training, which lasts for a year or two. The work is too heavy for any woman to do and the experience can be gained only by performing the actual operations in mixing and baking.

"We have found that this experience makes our chemists worth a good deal more to us than if we took them and relied only upon their chemical education."

From the laboratory department of a similar industry comes the following statement which suggests that methods of administration which have been followed up to this time might be adjusted to permit the employment of women chemists:

"We do not have women chemists in our laboratory for the reason that up to this time it has been necessary for our chemists to be able to do heavy physical work if called on to do so. Consequently, we have aimed to employ only able-bodied men of normal size.

"We believe there is a real opportunity in our line for women chemists, and we would not hesitate to employ a woman chemist if her training and experience qualified her for the position which we might have open."

The variety of laboratory work in this industry is evident in the experience of a woman chemist whose work consists mainly in the analysis of flour before buying and samples from carload lots after buying, for the thirteen bakeries of her company. She also has the analysis of other ingredients, such as malt, milk and shortening, and controls such matters as the blends of flour and times of fermentation. She considers the limitations of her position due to the fact that as a woman she cannot superintend the large body of men of the type which are in this business. "The woman who advances must have a very strong personality."

A woman with experience in flour analysis in a flour mill is now proprietor and manager of a commercial bakery employing three men and four women.

Baking Powder. This industry is naturally not an extensive one. In the census figures baking powder and yeast are grouped together; 84 establishments are reported to be engaged in their production in 1919 as against 124 in 1914. The value of the product grew from $22,339,000 in 1914 to $40,270,000 in 1919.

A baking powder manufacturing company which in 1917 was not employing women chemists for the reason that it considered its chemical departments "a training school for future superintendents, positions that we do not consider could advantageously be filled by women," was in 1919 nevertheless employing three women as analysts. The management found that "if they have had as good a chemical training as men, they compare quite favorably" and considered that their future prospects were good and depended only upon their capabilities.

In 1920 one of these women was assistant chemist testing ingredients used in making baking powder and doing some experimental work. She felt that if she were a man her work would prepare her for the position of factory superintendent, but was somewhat doubtful of her own opportunity for advancement.

Canned Fruits and Vegetables. The census of manufactures groups together both canned and dried[1] fruits and vegetables; the following interesting figures are given: 3190 establishments were manufacturing these products in 1919 as against 3250 in 1914, a decrease of 60 establishments. The value of the product on the other hand increased in this period from $158,016,000 to $416,145,000, or 163.3 per cent. Details of this increase are as follows:

Product	Value 1919	Value 1914	Percentage of Increase
Vegetables, canned	$164,619,000	$84,414,000	95
Fruits, canned	127,965,000	24,897,000	414
Fruits, dried	86,024,000	34,772,000	147.4
Soup, canned	11,857,000	7,877,000	50.5
All other products	25,680,000	6,056,000	324

(Including dried vegetables, preserves, pickles, cider, vinegar, etc.)

Canneries require a certain amount of scientific control, chemical, bacteriological, and microscopic; there is also constant need for development and research. The character of the water supply requires careful regulation. The utilization of waste products is an important problem to the food manufacturer and a difficult one to date because of the expense involved. Some by-products are suitable for the preparation of foods, a larger number for the prepara-

[1] See p. 104.

tion of stock feed or fertilizers. Occasionally new fungus diseases and unknown forms of spoliage or discoloration appear with which it is necessary to cope. Inquiries concerning the nutritive value of the food manufactured are referred to the laboratories.

It is the more progressive canneries which have established their own laboratories. The greatest amount of research for this industry is conducted by the National Canners' Association. In the laboratories of this association some of the scientific problems before the industry are considered to be:

1. Study of tin plate. Considerable progress has been made on this subject but there is some fundamental deficiency in tin plate by reason of which some runs of plate perforate badly with canned fruit. This question also involves the technology of can making and canning to some extent.

2. The penetration of heat in canned foods. Further work remains to be done, especially with reference to the distribution of heat in process kettles under different conditions.

3. Bacteriology of canning. A study is being made of the time necessary at various temperatures in various mediums to kill the spores of resistant bacteria.

4. The acidity of canned foods during the sterilizing process. It is necessary to know the acidity in terms of hydrogen ion concentration not only for the food itself but of the liquor filling the interstices of the food at all stages during the period of processing.

5. Process temperature and time. The data secured under the last three headings discussed should be correlated and theoretical process times for favorable temperatures should be calculated under different conditions of retort management. These theoretical processes should then be confirmed by means of experimental packs working with cans inoculated with resistant bacteria.

6. Special technological problems. It is necessary for the laboratory to be familiar with the technology in the industry in order that it may be in a position from time to time to determine the causes and find the remedy for unfavorable results that are obtained in the preparation of canned foods.

7. Cause of food poisoning. This subject is not related to canned food more than other foods. The canning industry, however, being the only food industry which maintains research work, is financing a general study of food poisoning, especially botulism.

8. Study of vitamines. The influence of heat on vitamines is only partly understood. We need to know this subject in greater

detail, especially with reference to the relative vitamine destruction that is effected by the canning operation and by cooking the fresh product in the kitchen in preparation for the table.

"In the two studies last discussed, a large part of the laboratory work thus far done has been done by women and they have made substantial contributions to the literature of vitamines. Regarding the other subjects mentioned, the field of women is somewhat more limited. They could, of course, in the laboratory, work as well as men. The work is intimately connected, however, with technological studies which necessarily involve field work that must sometimes be conducted under conditions for which women would not be appropriate. We have had women in this laboratory and they did creditable work. It is necessary, however, for us to have enough men to take care of all possible demands from the field."

The difficulties incident to the employment of women chemists in the canning industry are further amplified as follows by an officer of a company in which the work of the one woman chemist ever employed was "perfectly satisfactory":

"We prefer to employ men in our chemical laboratory, not because their chemical work is of a superior quality to that performed by women, but due more to the fact that during our rush seasons we often call upon our chemists to go out into the field to the different branch factories to take a hand in the practical work, which work at these particular seasons of the year is very exacting and hard; especially is this true during the tomato season when tomatoes are coming in very rapidly. At such times the matter of hours is forgotten, and of course it would be impossible to request a girl to do this work. For this reason when men are available we much prefer them in our chemical laboratory.

The point of view of several women chemists in the canned food industry, typified in the following comment, is that all these limitations can be overcome:

"Some men feel that a woman is afraid to do the heavy and dirty part of the work which comes in some lines. Personally, I feel that more women should take up chemistry as gradually men are coming to realize that women can and will do the work."

Manufacturers of cans are also vitally concerned in the chemistry of canned foods; their chemists work out such matters as the development of proper lining material, the preparation of alloy steels, or similar alloys for use as metal containers which will not be susceptible to perforations by acid fruits or discoloration with non-acid fruits.

Chocolate and Cocoa. The number of establishments producing chocolate and cocoa increased from 36 in 1914 to 48 in 1919, according to the census of manufactures. The value of chocolate and cocoa produced in 1914 was $35,712,810; in 1919 it had increased to $139,258,296.

For laboratory work in this industry a knowledge of cooking has been found valuable in addition to good general training in chemistry, especially organic chemistry.

A woman assistant to the general factory manager in a chocolate and cocoa manufacturing plant is the first chemist to be employed by her firm. She began by learning the details of the process of manufacture, collecting data and ordering equipment for the laboratory under construction and acting as inspector and sampler of all goods before shipment. Although she considers that there is still some prejudice against women, she is confident that she may advance as quickly as any man in the same work.

Dehydrated Foods.[1] The present situation in regard to the production of dehydrated foods and chemists engaged with the problems of this industry is summed up by the president of an anhydrous food products company as follows:

"At the present time we think we are accurate in stating that no food dehydrating company in the United States is employing a full-time chemist in its research work.

"Some of the large companies interested in drying problems through the sale of apparatus have chemists on their staff who are giving some attention to the chemical phases of dehydration. There are probably four or five such concerns.

"Quite an amount of work is being done by various universities and other similar institutions throughout the United States upon dehydration and in this work a number of chemists are engaged.

"It is generally conceded by all that dehydration is one of the most important future developments of the food industry. As a result several companies are making progress towards a successful and large scale business. We, ourselves, feel very confident as to the ultimate establishment of the industry on a firm foundation. At this time any company to be really successful will have to have its research chemist at work.

"The matter, however, must be conceded at the present time to be one of uncertainty and for the next two or three years it would

[1] For statistics see p. 101.

have to be said that the total demand for chemists would be rather restricted."

The condensed and evaporated milk industry is well established, even including the manufacture of the more recent powdered milk. The laboratories of these industries are responsible for control analysis of the products. There are instances of the successful work of women in this industry. For example:

A woman assistant chemist in a condensed milk company analyzes the product and assumes the responsibility of the laboratory when the chief chemist is away.

In a similar company a woman is director of the analytical work; her duties include the analysis of condensed milk in the main laboratory of the company and the responsibility for the reports of twenty-five subsidiary plants.

Flour. The census figures which indicate the extent of this industry are as follows: the number of establishments manufacturing flour mill and grist mill products in 1914 was 10,788; in 1919 the number reported is 10,714. The value of the products in 1914 was $877,680,000; in 1919 it had increased to $2,193,007,000.

In the manufacture of flour and other cereal products chemical analysis shows the varieties of cereals which are most likely to have a desired composition. Scientific control, including chemical analysis, the baking of test loaves, and other laboratory investigations, enables the mill to turn out flour of a more uniform composition and to diversify products to meet the wants of different sections of the country.

The field of pure research in this industry is vast and barely touched as yet, since the manufacturer is just beginning to recognize the significance of such research.

"Of course, there are not as many chemists in the flour line as one might expect, but all the large mills now have chemists and new ones are continually installing laboratories. As far as research work is concerned, there are great opportunities because no subject pertaining to flour or wheat has been emphasized very extensively." *(Head of laboratory department in a large flour mill.)*

"The limitations in our field are primarily due to the unwillingness of the miller to pay the price of real scientific service."

(Chemist in a wheat and flour testing laboratory.)

A research director in one flour laboratory with a staff of four chemists is working on problems connected with the causes of peculiar variations of wheats and other cereals when baked into

bread or used for other food purposes; with the improvements of methods of separation of wheat proteins and methods of quantitative analysis; with the chemical causes of loaf expansion and effects of various activating materials in bread making.

General chemistry, with special training or experience in cereals, is a basis for control work. For progress on the problems involved thorough preparation especially in organic chemistry is essential.

Comments from women chemists in this industry emphasize the service aspect of their work:

"I know in my own mind that millers—especially small millers— are not making the most of their laboratories in a practical way, but it seems almost impossible sometimes to make them see the possibilities.

"I had become almost hopeless of making my own firm see the light, but I think now the awakening is gradually coming. I am not so much interested in the strictly scientific end of cereal chemistry, but I do wish to make the laboratory a practical business asset, using it to perfect and standardize our product as well as to reduce costs. This can only be done by the chemist's having an understanding of the business as a whole—the wheat buying, sales and general aspects of the business. Otherwise the chemist becomes simply a tester or glorified cook with no chance to interpret and apply results of tests."

"Analysis of flour, mainly for percentage of gluten, ash, and moisture; testing by experimental baking; milling of wheat samples and analysis of resulting flour; occasional analysis of feed."

"My interest has always been along the practical lines of determining proper wheat mixes for best milling, keeping flour products uniform in quality, checking up yield of flour, etc., rather than the scientific investigational lines. I think, however, mills want this sort of service and look to the Bureau of Chemistry of the Department of Agriculture for research work."

"My work consisted of the oversight of the quality of the products from flour mills, 14,700 barrels of flour daily, educational work for the benefit of baker customers, cost determinations based on experimental milling, some advertising in the way of articles for magazines, talks, newspaper advertisements, etc."

Meats. The figures of the census of manufactures on the packing industry, the largest in the country, are as follows:

	Number of Establishments		Value of Product	
	1919	1914	1919	1914
Slaughtering and Meat Packing	688	649	$3,714,340,000	$1,454,495,000
Slaughtering (chief product, fresh meat)	605	630	281,417,000	197,470,000
Canned Fish	619	538	121,694,000	55,283,000
Canning and Preserving Oysters	65	65	2,976,000	2,238,000

The packing house laboratory has done much to improve the main products and has greatly assisted in the elimination of waste, largely by means of the production of by-products of so varied an extent and so great a volume that it is probably for their production that the packing house is chiefly famous.

There will always be a demand for chemists, particularly organic chemists, in this industry, since so many of the processes are dependent upon chemical control and the by-products are sold on chemical analysis.

One large company which started just a few years ago with one chemist now employs about 100 analysts, research chemists, "commercial" chemists, and chemical engineers.

The work in the laboratories of this industry covers a very large range of subjects; it is difficult to find any laboratory in which the work in organic chemistry is so diversified.

"There are many problems in our industry that remain unsolved and there are many processes which are capable of considerable improvement especially along the lines of salvaging waste products. It is common knowledge that in our industry too many things go into tankage, which in so far as the protein content is concerned means it will be used as fertilizer. Our problems involve the saving of protein for edible purposes and human consumption so far as it is possible, and if not for human consumption then for animal food. We have problems in glue and gelatine, in refining and bleaching of edible oils, in making soaps, in pharmaceutical preparations made from the glands of animals and so ad infinitum." *(Superintendent of laboratories in a packing company.)*

"Some of the things we are called upon to solve are as follows:

"To determine yields under various conditions of manufacturing oleomargerine.

"Experiment and changes in pickling solutions for curing meat in order to improve the flavor, keeping qualities, etc.

"Improvement of methods of deodorizing oils for oleomargarine purposes." *(Chief chemist in a company of packers and provisioners.)*

Women chemists have been found satisfactory for laboratory work in the packing house industry and women trained in domestic science as well as in chemistry have done educational advertising and domestic science research. Some chief chemists find limitations for women in this industry, however, as in others:

"In our industry so often a chemist is required to go into the plant either to obtain samples or to observe certain operations connected with the work he is doing and it is impossible for a woman to perform this kind of work."

"The great difficulty is that the laboratory is largely a training plant for plant operators, and there does not as yet seem to be an opportunity for women in the operating departments of the packing house."

Yet there are chief chemists in this industry who hold a different point of view: "I cannot see that there are any inherent limitations for women chemists. I think the outlook in chemistry as a vocation for women is especially good."

The point of view of a woman chemist with experience in this field is this: "Inasmuch as laboratory work in a commercial field leads to field work in factory management, research and chemical engineering problems, the opportunities are decidedly limited. Women have not yet been permitted to enter these branches because of supposed *physical* inability. In my mind this is unjust prejudice."

Oils. The world war brought a keen realization of the international struggle for oils—edible oils as well as those used for lubricants, soaps, explosives, etc. The chief sources for edible oils, aside from meat and dairy products and olive oil, are cottonseed, cocoanuts, peanuts, corn.[1]

As a result of the chemist's work the cottonseed which had been looked upon merely as a source of expense for its removal has become the raw material for two important products, cottonseed oil and cottonseed press cake. These two products have added from 10 to 12 dollars to the value of a bale of cotton and afford occupation to thousands of people engaged in their production and sale. Census statistics for the production of cottonseed oil and cake report 882 establishments engaged in their manufacture in 1914, 713 in 1919. The value of the product had grown in that period from $212,127,000 to $570,213,000.

Dr. Slosson points out[2] as further possible sources of vegetable

[1] See p. 98.
[2] Creative Chemistry, p. 213.

oils the seeds of tomatoes, pumpkins, poppies, raspberries, tobacco, cockleburs, hazelnuts, walnuts, beechnuts, acorns.

A leading manufacturer of vegetable oils sees the problems of the industry at the present time as two-fold:

1. Improvement in analytical methods with a view of securing a better knowledge of the materials which go to constitute the loss in refining of vegetable oils.

2. The devising of methods to reduce the loss.

Another important problem is to find out why Fullers Earth bleaches fats and oils. "We also have the everlasting carbon problem, to find out why certain carbon bleaches and how to improve its bleaching properties.

"It is only fair to state that these are problems which many of us have been working on for years and we are only beginning to see the light. It therefore means considerable work for the prospective student to first acquire the facts regarding these problems before said student will be in shape to tackle them.

"In my opinion, there is a good field for women chemists in laboratory work connected with the oil industry. They are particularly well adapted to carrying out careful analytical work and research work pertaining thereto. In reference to limitations for women chemists in our field, they are better adapted to large laboratories which are connected with large plants, or better yet, with centralized laboratories for general control and research work. I do not consider women well adapted to small control laboratories in isolated plants, where the chemist is frequently called upon to do everything from making analysis to pipe fitting."

Sugar. The extent of the sugar industry in the United States is shown by the report of the census of manufactures to be as follows:

	Number of Establishments		Increase		Value of Product		Percentage
	1919	1914	No.	%	1919	1914	of Increase
Beet Sugar	85	60	25	41.6	$149,156,000	$62,605,000	106.3
Cane Sugar ...	202	181	21	11.6	57,741,000	21,635,000	166.7
Refining	20	18	2	1.1	730,987,000	289,399,000	152.6

This food is a product whose manufacture is peculiarly a chemical industry. In the growing and improvement of sugar cane and beets, selection is guided by chemical analysis; every step in the manufacture of sugar gives evidence that the industry is largely in the hands of chemists. The result has been the enormous cheapening of sugar, the simplification of the methods of manufacture and the utilization of the by-products of the industry.

The College of Hawaii has a standard four-year course in sugar technology, divided into an agricultural division and an engineering division to train for the two phases of the industry, the growing of cane, and its manufacture into sugar. Work on a sugar plantation or in the experiment station of the Hawaiian Sugar Planters' Association in vacations supplements the technical training.

Louisiana State University has also established a sugar school. The chemistry included in these courses consists of fundamental work in inorganic, organic and physical chemistry, the principles of sugar analysis, complete technical analysis of cane, bagasse, juice, syrup, molasses and sugar—determining sucrose, glucose, glucose ratio, real and apparent purity, etc.

The need for chemists in this industry is a continuous one. The demand for analytical chemists or "bench" chemists in the control laboratories is to some extent seasonal as is the industry. "We have to take on a large number of employees every fall shortly prior to the time the campaign starts without being able to offer them any prospect of permanent work, except in the rather rare contingency that a man can get ahead fast enough to be put into a position where permanent employment can be given him."

Some of the problems engaging the research chemists in this industry are the increase of the efficiency of the processes, the reduction of sugar losses, the improvement of the quality of the product, the development of by-products—recovery of nitrogen and potash, sodium cyanide and certain rare organic chemicals, production of glycerine by fermentation of waste molasses, recovery of organic acids from waste waters, and the reduction of fuel, lime and filter consumption.

Women have done satisfactory work as analytical chemists in sugar laboratories. As in other industries, there is doubt in the minds of employers as to the suitability of women for work in the plant, although the difficulties stated do not seem insuperable:

"It is only fair to state that there is very little future in this company for a woman chemist because in any of the higher positions, including that of assistant chemist, a large part of the work takes them out into the factory, where they run up against an ordinary class of labor, and where they are required to deal with and handle heavy machinery; in other words, a class of work which we do not consider it suitable to entrust to a woman. We have, however, now in our employ two women as assistant chemists, who are engaged on special analytical work, wholly within the laboratory, but it is difficult to see how we can offer them much further advancement.

"We are very well satisfied with the results which we have had, to the extent that we have employed women as chemists. As bench chemists I consider that women of equal chemical training are just as competent as the average man."

(*General chemist in a sugar company.*)

Yeast.[1] The place of the chemist in the yeast industry is evident from the following description of a woman's work in a plant manufacturing this product:

"For the first two months the work was purely analytical (not routine) of a general laboratory, involving grain, molasses, vinegar, coal, highly accurate standardizations, etc. I was then transferred to the research department where the work consisted of all problems involved in the growth of yeast, both from a purely scientific and industrial standpoint (chemical rather than bacteriological). Twenty or more experimental mashes were run daily in connection with this work."

Women have been extensively employed in this small industry both for control and research work. A knowledge of bacteriology as well as organic chemistry has been most valuable. The positions for which women have been employed by one company have been described by the head of the research laboratories as follows:

1. Without previous chemical training workers are limited to from one to four different kinds of standard routine tests.

2. College graduates are employed for straight analytical work of a slightly complicated nature under the direct supervision of another chemist.

3. Chemists with five to six years of college and from a half to one year of previous laboratory experience are employed to carry out experiments without continuous supervision.

4. A chemist with a Ph.D. is given complicated organic analytical and research work.

"The only two fields in which women have not as yet been tried out are chemical work in the factory and absolutely independent research work.

"We are not trying to limit our women chemists to routing analytical work, but to the contrary, are trying to give them every advantage to prove their ability in the widest fields."

Gases. In addition to the production of gas from coal[2] and from wood,[3] acetylene gas,[4] the fixation of nitrogen,[5] various indus-

[1] See p. 101.
[2] See p. 91.
[3] See p. 147.
[4] See p. 90.
[5] See p. 83.

trial gases, compressed and liquefied gases, are manufactured by chemical processes involving chemical control and demanding chemical research. In one company, for example, the problems consist in the extraction and purification of the elements of the air and the development of uses for these elements. "One problem at the present time is the development of new uses for neon, one of the rarer elements of the air. Other problems are the obtaining of more extended information regarding the properties, both physical and chemical, of these and other industrial gases such as acetylene. This work has never been completed and we are constantly striving to increase our knowledge on this subject."

A consulting chemist who specializes on the subject of industrial gases pronounces the field one in which research and intelligent chemical development work are necessary, and believes that the future demand for chemists in this particular field is limited only by the rate at which real progress is made within the field. He sees no inherent limitations for women chemists but considers it rather a field of chemistry for which the woman chemist is particularly fitted. As suggestive of the problems pertinent in this industry, the following are cited:

1. In the manufacture of oxygen and hydrogen gas by the electrolysis of water, a determination of materials and conditions that make for the maximum productive capacity.

2. A determination of the explosive limits of oxygen in hydrogen and hydrogen in oxygen.

3. A determination of the exact reactions of high temperature flames using oxygen as a supporter of combustion, using hydrogen as the combustible gas.

4. A more accurate determination of the chemical characteristics of acetylene gas with particular reference to the conditions under which this gas will be compressed.

5. A determination of the effect of impurities in oxygen gas when used in the autogenous cutting process.

6. A determination of the electrical reactions involved in the autogenous cutting process to enable a determination of the effect on the economy of the process by changing the combustible gas.

All of these specific problems deal somehow or other with the purity of the gases involved which as a factor of primary importance in the commercial application of any process involving industrial gases. Satisfactory methods of analysis, which are sufficiently convenient for the continuous use necessary in the continuous application of these processes, need to be worked out. Simple methods

of analysis for minute quantities of impurities in gases have not been perfected to the point where continuously accurate results are assured and in dealing with very pure gases, continuously accurate results are essential.

Leather. The statistics of the extent of the leather industry, tanned, curried, and finished, as reported in the census of manufactures indicate 683 establishments engaged in its production in 1919, a decrease from the 741 establishments reported in 1914. The product had, however, nearly trebled in value, $367,202,000 in 1914, $928,584,000 in 1919.

The new synthetic tanning materials derived from coal-tar products have already been referred to,[1] as has the development of artificial leather.[2] In the leather industry proper there is further need of the chemist.

Very little is as yet known of the chemistry of leather, which is based upon physical (particularly colloid) and organic (particularly physiological) chemistry, and upon bacteriology and physiology.

The tanners in general have been conservative in adhering to rule of thumb methods, and have just begun to recognize the importance of a scientific study of their industry. However, a number of firms have made provision for research in their own laboratories while some individual firms and a trade association, The Tanners' Council, are supporting important leather research both in industrial and in university laboratories, and it is reasonable to expect an increasing demand for chemists in so new a field.

The Department of Leather Research at the University of Cincinnati employs two chemists, two bacteriologists and a technician. At Columbia University Mrs. Mabel Baldwin Gerard was for a time in charge of the leather research for which a special fund has been provided. She produced valuable results which have been recognized in this industry. Margaret Kelly is now working on similar problems in the same laboratory.

One chief chemist in a leather factory points out that the most pressing problems of the leather industry involve microscopic and physico-chemical investigations. For example, a thorough investigation of the structure and components of skin and of their chemical and physical properties is needed. "We desire also to get a better understanding of the action of alkalis upon the Malphigian layer of the epidermis, of the action of enzymes upon all of the

[1] See p. 93.
[2] See p. 66.

proteins of skin, of the molecular mechanism of tanning, and of fatliquoring.

"Our industry needs chemists very badly. The number of *real* chemists in the industry in America can be counted on the fingers of one hand, but the tanners themselves, with few exceptions, do not yet appreciate the value of chemistry. This condition will probably change in a few years, when the demand for thoroughly trained chemists should be brisk.

"This kind of work can be done by women chemists as has been proved by the leather chemistry researches of Misses Baldwin and Kelly at Columbia University. The only limitation for a woman chemist would be the limit of her own mental ability. We usually find women to have more limited powers of reasoning than men, but this is probably due to their early training, and not to the fact that they are women. I see no reason why a woman properly trained from childhood should not equal a man similarly trained. Women are usually more careful, painstaking, and patient than men, but this, too, is probably a matter of early training. I believe there will be a demand for both men and women chemists in the industry."

Metals. In the winning of metals from their ores and their refining, in the making of alloys, in manufacturing metal products, the direction, control and research of the chemist are essential.

There is need for continued research upon alloys of metals; the microstructure of metals; the corrosion of metals—the effect of corroding agents and the influence of the various constituents of alloys upon corrodibility. New and better methods of production are constantly growing out of scientific research; for example, electrolytic copper is a development of only recent years and now has a leading place in the market; electrolytic steel is satisfactorily developed, electrolytic iron is new.

In the fact that not half of the more than 50 metals which are known[1] have come into common use, there is a challenge for further constructive research.

Alloy Metals. The rarer metals used in making alloys—manganese, tungsten, titanium, molybdenum, vanadium, etc., are in some instances separately manufactured; frequently their reduction and refining are combined with the manufacture of the alloys.

Laboratory analysis controls the production; problems concerned with the development of new alloys, new processes for the

[1] Creative Chemistry, p. 220.

extraction of alloy metals from different minerals, qualities of alloys, and the like are constantly arising for study and solution.

Aluminum. The census of manufactures reported in 1914 that 37 establishments were engaged in manufacturing aluminum or aluminum products; this number had grown by 1919 to 84. The value of the product increased in this period from $19,597,000 to $69,474,000, a gain of 254.4 per cent.

The reduction of aluminum from the ore is an electrochemical process. Each plant has its laboratory for analysis of materials used in production and of the metal produced. Since the process is of comparatively recent development, there are many problems still to be solved in connection with electrolysis, the utilization of additional kinds of ores, the production of new alloys of desired qualities and of by-products.

The chief chemist of an aluminum company in whose laboratories eleven women were employed during the war, a few of whom are still retained, found that their work "compared favorably with men, considering the fact that women are seldom as well prepared as men are." He has given thoughtful attention to the question of the employment of women chemists in this industry and expresses the judgment of the laboratory executives associated with him as follows:

"It is our opinion that the opportunity for women in our laboratory department will be limited strictly to the laboratory. In this connection their greatest opportunity will be analytical chemistry and of necessity the most of this work is largely of a routine nature.

"There is some opportunity for research work for women in our laboratories, but it seems to us that the opportunity is somewhat limited. There is very little research that we do which is of a purely academic character; as it progresses it inevitably necessitates a considerable investigation in the factory itself. It seems to us that it is practically impossible for women to conduct factory investigations successfully. Much of our research work, when it is transferred to the factory, is plain hard work of a physical nature. I have no doubt that the women research chemists will be willing and competent, but I do not think it would be a practical success for them to undertake what we may call industrial research work.

"I should not consider the future especially promising for women chemists in our laboratory. As a general proposition, it is highly probable that those who are now with us or those who may be employed in the future will remain in the same positions that they now occupy, owing to the practical difficulty in the necessity

of frequent transfers, advancement to positions that could scarcely be held by them, the necessity of having a staff that we can call upon to do almost any kind of work, and last but not least, the more certain tenure of position by a man than by a woman.

"Since the armistice we have employed one woman chemist as an assistant to our physical chemist. This woman studied especially mathematics and physics, and makes a very good assistant. We also have employed a woman metallographist since the war, and it seems to me that this work, which involves painstaking care, together with a knowledge of photography, is well suited to women."

Of the women remaining in these laboratories one was for six months in the carbon laboratory. When the force was reduced, she was transferred to the general laboratory where she analyzes aluminum for copper and iron.

At another plant a woman became assistant chemist and has charge, in the absence of the chief chemist, of the laboratory employing 12 people. She herself does a part of the control work, analyzes anything the superintendent of the plant sends in, works out methods, checks up the daily work, standardizes selections, etc.

Of these two women the former is satisfied with her situation and feels no limit to what she may look forward to; the latter finds her work very interesting, "fascinating," but feels limited in her inability to carry her training and knowledge outside of the laboratory into the plant.

Copper, Brass and Bronze. There were 37 establishments for smelting and refining copper in this country in 1914, according to the census of manufactures, 33 in 1919. The value of the copper produced increased in this five-year period from $444,022,000 to $632,897,000. In 1914 there were in addition, 992 establishments manufacturing brass, bronze and copper products; this number had grown by 1919 to 1122 and the value of products had increased from $162,199,000 to $487,707,000, a gain of over 200 per cent. Arizona is the leading state in copper smelting, New Jersey in copper refining.

In the evaluation of ores, the reduction of copper from its ores, in the making of the many alloys—brass, bronze, German silver, etc., in which copper is a basic element, in the plating of copper, chemists control the processes by constant analysis and develop better methods and new products through research. The field of non-ferrous metallurgy is a special one in which the demand for chemists has been steadily increasing, especially with the introduction of electrolytic methods.

Electrolytic refining of copper, electroplating, the recovery of by-products—gold, silver, platinum, palladium, selenium, tellurium, arsenic, nickel, antimony, the heat treatment of metals and alloys in general, the determination of their properties and the modification of these properties by various methods, are all matters of current interest in research in this field.

The copper and non-ferrous alloys industry has in general operated on the principle that women are not suitable for plant work, although in at least one instance a woman has overcome this limitation.

"So far as laboratory work is concerned, we know of no inherent limitation for women chemists or those who are schooled in metallurgy. Young men frequently move from the laboratory into works positions, but this opportunity would not be open to women on account of the nature of the work which in metallurgical establishments of our kind is heavy and more or less dirty. . . . There is no reason why women should not be able to carry out laboratory research as applied to this industry; the carrying out of research on operations in the mills necessitates work with furnaces and in casting shops which women generally are not physically fitted to undertake."

(Technical superintendent and metallurgist in a brass company.)

"In the non-ferrous alloy field, there are, we believe, limitations to the activities of women chemists. Certain research problems require a great deal of work in the shop, and it means, in many cases, getting out among men, working side by side with them and gaining their confidence before anything can be accomplished. A man is much better fitted for this type of work than a woman. If the work is confined to the laboratory, however, there are no inherent limitations for women chemists unless the work requires some heavy manual labor which a woman is not physically able to perform. She could easily be assisted over these obstacles when they occur. I believe that the outlook in chemistry is very bright; the field is large and varied and opportunities and possibilities are unlimited to women as well as men chemists."

(Chief chemist and metallurgist in a company manufacturing non-ferrous alloys.)

In one company in which women chemists have been employed for several years the experience is summarized as follows:

"During the war this laboratory first employed women chemists, the maximum being 16, 9 employed at the present time.

"In research work I did not obtain the results anticipated,

which, on analysis, I found to be due entirely to their not being willing to devote any of their own time to the work in hand.

"On account of plant conditions they were not tried out on experimental work that required going about the plant.

"They did make good in control analytical work on routine analysis, when after being properly broken in they excelled the male chemist in speed and accuracy.

"I early learned that it was necessary to arrange the women's work so that the most important details should be done in the morning, and that after lunch when the fatigue of labor began, to have the more mechanical parts done.

"Many concerns have found that employing women workers has decreased the efficiency of the force inasmuch as many women will take advantage of the many feminine arts and wiles, but this does not apply to a trained worker.

"My advice to a woman about to enter the industrial chemical work is to bear in mind that first of all she is a worker, to expect to be treated as such, and she will find that promotion comes to the able worker with pleasing personality of whichever sex; not to be over sensitive or over prudish and adhere somewhat to the Golden Rule." *(Chief chemist in a metals refining company.)*

Frequently the feeling that women are unsuitable for certain kinds of work is primarily chivalrous—the unwillingness that women should do dirty work or hard work or be exposed to a trying environment. "A great deal of work about a laboratory requires a chemist to get out into operating conditions, and as women could not be expected to do this, there would probably not be much opportunity for them to become directors of plant laboratories.

"There are decided limitations on the kind of work that can be given to women, whereas men can be given any kind. I should say that a commercial laboratory is not at all suitable to a woman. The work is nearly always hard and the handling of acids, etc., does not appeal to the best kind of woman."

(Chief chemist in a copper company.)

The women who have had experience in this field do not feel hampered by these limitations. Two analytical chemists in a copper company, whose work includes the analysis of nickel solutions, oxide and metallic nickel for percentage of nickel and impurities; the analysis of refined copper for impurities, such as lead, nickel, sulphur, iron, selenium and tellurium; the analysis of oils, fuel and lubricating, for sulphur, flash and fire point, and viscosity;

the analysis of slags, brass and slimes, hope with further study to become expert metallurgists. Their point of view is expressed by one of them as follows:

"Personally, I think chemistry a splendid vocation for women if they are interested in their work. Of course, it has its drawbacks as, in my case at least, the work isn't very clean and is pretty hard on the hands and clothing. But it never becomes monotonous, and there is always so much to learn that you don't think of it as work at all."

A woman with considerable experience in the laboratories of a copper plant, who combined with her chemical work some employment work, and the training of employees for the laboratory, writes of the possibilities of executive work in the laboratory:

"I personally think that there is great opportunity in the industrial field for the woman with scientific training, some business and executive ability, and an adaptable personality. The ordinary factory laboratory is a dingy, crowded, makeshift sort of a place, very unlike the workrooms of school or college, and the lack of proper accommodations in many cases makes it impossible to employ women and girls. Certain kinds of laboratory work require too much physical labor, too many consecutive hours of standing or too much running about the mill to permit of the employment of women. Many factories are situated in such inaccessible spots that women can't get to them or don't care to live near them. In the laboratory with fair accommodations where the work permits some systematization and division of labor, and is not of too arduous a character, a force of women and girls works out better than one of men and boys. One or two college women in charge can manage the work as well as men and attend to the detail more successfully. As helpers girls are far superior to boys. They are more neat, careful, conscientious, and loyal. They are used to doing things with their hands, have more patience and take more pride in detail. They will stick to their job indefinitely because they have no ambition to become president of the concern. Boys stay long enough to learn the routine, then want to move on to another department. Girls learn the routine, are unwearied by it, and will stick to it until they get married. The opportunity for the college woman is in the organization and management of such laboratories. Of course, there is much research work and ordinary analytical work that the women can take over, but the more executive positions are usually better paid, and do not require as much training and practical experience. The ordinary college graduate can

handle girls successfully, and with perhaps one year of experience under an experienced chemist should be able to run a factory laboratory. She cannot, of course, do the outside work in the mill that a man can. She must stay in the laboratory, and the laboratory is not as remunerative as the business and technical end, but she can earn more than at teaching or secretarial work, if she is willing to work eight or ten hours a day and is content with two weeks' vacation."

In another copper company a woman is charged with the supervision of a small department of the laboratory with three assistants for routine analysis of copper bullion. "Chance for original expression is only in organization and in the development of greater efficiency. It is a new field, women must first find, then establish their place. They are fitted for the work but must prove it to skeptics."

Finally, there is the record of a woman who has overcome the usual handicap and gained the opportunity to go into the plant where, in overalls, she successfully handled the hard work and commanded respect from the labor group. After six months of analytical work she had outstripped three men and was given the title of assistant metallurgist, and has also done some research. She considers engineering, cost accounting, and business organization important in the preparation for industrial chemical work since it must always be borne in mind that the plant is a business organization in the control of whose cost and management the laboratory plays an important part.

Iron and Steel. The census of manufactures reports the following figures for iron and steel production:

	Number of Establishments			Value of Product		% of
	1919	1914	Increase	1919	1914	Increase
Blast Furnaces ...	195	160	35	$794,467,000	$317,654,000	150
Steel Works and Rolling Mills ...	484	427	57	2,812,775,000	918,665,000	206

The production of steel is absolutely controlled by chemical analysis; no heat is tapped until such analysis shows the product to be within the specifications. This means the busy kind of laboratory which requires what one woman describes as "a very steady head which is not lost by the necessity of attending to five or six things at the same time while the telephone rings every minute for analyses."

All pig-iron is carefully analyzed—five samples are taken from

each car-load received by one company. All limestone used in the open-hearth process is sampled and analyzed, as is also all coal. The most careful methods are worked out for determining in iron and steel the content of carbon, chromium and vanadium, copper, manganese, molybdenum, phosphorus, tungsten, hydrogen, nitrogen, oxygen and carbon monoxide, silicon, aluminum, titanium, sulphur. What this may mean for the analyst is illustrated by one woman's description of her work in a steel mill laboratory: "All day samples or tappings at the rate of one every fifteen or twenty minutes came in; I weighed up standard samples of steel in the correct amounts to determine the percentage of sulphur, phosphorus, manganese, carbon, nickel, chrome and pig-iron contained in the steel. For each element a different process is used. On my first job I ran sulphur, phosphorus and manganese determinations; on my next job I ran silicon, nickel and chrome; on my third, carbon, and on my fourth, silicon, sulphur and manganese in pig-iron."

A well-equipped research laboratory is considered essential in carrying out a high grade manufacturing program. In the early days chemistry had not in most cases been applied to practical steel making beyond the determination of the elements known as the "big five," sulphur, phosphorus, carbon, manganese and silicon. Today through research development it is known that gases such as nitrogen and hydrogen are elements to be considered in rust-resistance and other qualities of iron and steel. A close study of protective coatings with steady effort to improve further their quality and character is an important branch of metallurgical research. New uses for various iron products make necessary a constant expansion of research work, covering such lines as vitreous enameling, japanning, welding, heat treatment, forging and casting. New alloys, the result of special manufacture and treatment, must be developed from time to time to meet the exacting demands of industrial progress.

Iron and steel plants in various parts of the country have employed women in analytical and research laboratories. Plant work has not been considered suitable for women. "There is no doubt in my mind that certain classes of laboratory work can be carried out by women, but in our particular investigational line where it is necessary for the investigator to go into the mill to study the problem with the workmen, we believe that women are not adapted to this particular work."

(Director of the research department of a rolling mill.)

A woman with nine years of experience in secondary school and

college teaching entered the control and research laboratory of an iron company where she was later given charge of the laboratory. "I have the supervision of the laboratory where control and research work is done daily on all melting furnace heats of all five plants of the company. Routine analyses for silicon, manganese, sulphur, phosphorus and total carbon are made daily from samples of iron poured in these plants. Every car of pig-iron or coal used is analyzed in the laboratory. . . . Men, here as elsewhere are still in the lead. In industrial work they are nearer an equality in salary, in opportunities for advancement men's chances are better than women's. . . . Opportunity for advancement, however, is the same as is offered in almost any other field, depending upon the woman herself, and her ability to demand and secure it.

The war emergency influenced laboratory directors in this field also to employ women chemists for the first time. The results in one steel plant were reported by the chief chemist at the end of six months as follows:[1]

"On June 17, 1918, four young women from the University of Chicago began work in our chemical laboratory. One woman was assigned to work on silicon, sulphur, phosphorus and manganese in pig-iron; another on combustion carbon in steel; another on sulphur, phosphorus and manganese in steel; the remaining one on silicon, nickel and chrome in steel.

"I say it to the discredit of no man, but to the credit of the women, that they learned the work as quickly as any men of like training could have learned it. They were intelligent, attentive, earnest, anxious students, and soon learned to do the work assigned to them in a very creditable manner. They were and are careful, conscientious, reliable workers in the field of industrial chemistry, taking their turns at night work cheerfully, and so far as I can learn, contentedly. From these four women, I learned of others, and they were employed. During the month of August there were ten women employed in our laboratory, doing chemical work efficiently and successfully.

"The following may prove interesting, keeping in mind that women were first employed June 17th. During the month of July there were employed on iron and steel work, thirty-one men and seven women. Total number of determinations made in July on iron and steel, 68,798; made by women, 10,741, or 15.6 per cent of the total. Per cent of women employed 18.5—not quite their share; they were learning the work.

[1] An Evaluation of the Woman Chemist—The Chicago Chemical Bulletin, February, 1919.

"During the month of October there were thirty-six men and an average of six and a half women employed on iron and steel work, three women leaving during the month, two to go back to school, one securing a better position. This to explain the one-half woman. Total number of determinations made in October on iron and steel, 66,956; made by women, 10,721, or 16 per cent of the total. Percentage of women employed, 15.3. From this it is readily seen that as soon as the women learned the work, they carried their share of the work. During the hot weather of last summer, when to sleep, for those working at night, was almost impossible, the percentage of women off duty was less than the men.

"The percentage of women off duty on account of sickness is not greater than the men. In fact it has not equalled the men in our particular case, several of our men being on extended sick leave.

"Requests for days off duty by women are not excessive, and are not more than those of men.

"I have not observed in these women that outward expression of that inward feeling of the dark brown taste of the day after the night before, that sometimes is apparent in men. As a rule they are more cheerful, and from their smile I am led to believe that they are more happy in their work. They have added tone to our laboratory by their pleasing personalities. They have proved beyond a doubt that they can do and will do at any hour of the day or night, careful, conscientious, reliable chemical work. They have passed the crucial test of service. They have been weighed in the chemical balance and not found wanting."

This report pertains to the routine work required in an iron and steel laboratory. The chief chemist declares himself unqualified by lack of experience to express an opinion in regard to women working on research problems requiring plant or shop work.

"With the signing of the armistice war work ceased, and the amount of chemical work required for the operation of the plant soon dropped to less than half of what it had been. The chemists that had enlisted or had been drafted were returning and requesting their old positions. It seemed only fair to give the soldier boys their old jobs. This was apparent to the women chemists. Acting true to form they all appeared in my office one morning and resigned, resignation to take effect at my discretion, stating that it was their desire that I give the returning soldier boys their old positions. This was done. I regret that I now have no women chemists, due to no fault of theirs I assure you."

The women concerned in this experiment with one exception

found it satisfactory, although recognizing little opportunity for advancement. Some of their comments follow:

"Without a doubt it was a wonderfully interesting work. The men with whom we worked were almost all college men and treated us with the greatest respect. If all employers were thoughtful and considerate and gave their girls as much encouragement as was given us there is no doubt but that more girls would want to enter this new field, and in time I think they will be equal to any of the men chemists."

"I believe if more women became interested in chemistry and could prove their worth as good, able chemists, there would constantly be more fields open to them. It is not by any means dainty work; it is fascinating for one really interested. There is little opportunity for advancement in steel chemistry."

"Chemistry is one of the coming vocations for women. It requires careful, conscientious work, and women have these characteristics to a greater extent than men. Steel chemistry requires physical strength and endurance. I think in time a woman might become chief chemist for a large concern."

Lead. For the lead industry the census of manufactures reports the following:

	Number of Establishments			Value of Product		% of
	1919	1914	Increase	1919	1914	Increase
Smelting and Refining	25	22	3	$632,897,000	$444,022,000	42.5
Bar, Pipe, and Sheet	31	27	4	16,802,000	7,431,000	126.1

At lead mines and mills chemists test samples by electrolytic and titration methods, for percentage of lead present. The manufacture of lead into alloys, finished products, paint bases, etc., involves chemical control analysis with investigation of pigments, opacity of paint films, cooling and hardness of alloys, etc.

In one company, a woman was employed on a special investigation covering a year, with reference to the reflection of light from pigments.

At a lead mine and mill a woman has worked in the testing laboratories; they were situated in a crowded mill yard and were noisy and dusty; no other woman was working within two blocks in any direction. In spite of such external disadvantages she sees no reason why women should not rank with men in most branches of this work. "Some of the research, however, with which I have

come in contact, has required a technical background of mechanics, a knowledge of the electric furnace, etc., which perhaps would not be desired by many women. All the other work could be done by a woman just as well as by a man except work in testing mill machinery which should be done by a special mill tester rather than by the chief chemist."

Zinc. The census of manufactures indicates 38 establishments engaged in the smelting and refining of zinc in 1919 as compared with 29 in 1914. The value of the zinc produced has increased from $53,538,000 to $103,103,000.

In this industry chemists are concerned with the testing of zinc ores, the fundamental reactions in zinc smelting, the condensation of zinc, electrical precipitation, the production and properties of worked metallic zinc in the shape of sheets, rods, tubes, etc., the manufacture and use of zinc oxide in rubber and paint industries, research on zinc chloride, etc.

A large zinc company took on six women chemists during the war for analytical and research work. They were retained after the armistice. The company sees no reason why it should not continue to employ women chemists along the same lines, commenting, however, through the employment department:

"As routine chemists women do fairly well. They hesitate to accept responsibility. Women chemists as a class we consider less constructive, chiefly due to the lack of their understanding of the application of science to industry. Our general criticism is that most of the women chemists do not take the work seriously enough and therefore do not make a consistent effort to extend their knowledge in order that they may fit themselves for more advanced work."

The women chemists in this company, meantime, evidently did not all sense their opportunities for extended knowledge and more advanced work. One of them comments:

"Work in chemistry is and will continue to be a very agreeable and satisfactory vocation for women. However, I would not advise women to be trained for or seek positions in metallurgical work as all opportunities there lie in plant work. There is some chance to do research work, but the greater part of it is done in the plant or on a plant scale."

Yet some very theoretical work on colloids was being done in the research laboratory of this plant, in which a woman analyst was assisting.

It is worthy of note that the one woman with the best prepara-

tion, a master's degree, felt herself "greatly hampered" by insufficient training, though she had secured promotion to the supervision of a laboratory connected with an experimental plant dealing with problems of de-leading zinc ores.

Precious Metals, Gold, Silver, Platinum. The census of manufactures gives the following statistics for gold and silver:

	Number of Establishments			Value of Product		% of
	1919	1914	Increase	1919	1914	Increase
Reducing and Refining	87	78	9	$55,483,000	$28,588,000	94
Leaf and Foil.....	87	79	8	4,462,000	2,432,000	83.4

Manufacturing jewelers are also to some extent refiners. In jewelry manufacturing in general well-accepted methods prevail and there is little recognition of the value of scientific investigation. It has been estimated by a chemist in this field that the absorption capacity for chemists of the whole field of precious metal refining and jewelry manufacturing would not exceed 40 to 50, but that it is highly desirable that the present indifference of the industry to the possibilities of scientific development be overcome. For instance, gold and silver electroplating is a field for research.

Platinum is a more recently found metal, its ore is much more complicated than that of gold and silver, and the methods of its analysis have not been so well developed. Hence the greater need for scientific knowledge in working with platinum. The reduction of platinum from its complex ore, consisting of the metal in combination with varying proportions of the other members of the platinum group, such as iridium, rhodium, palladium, ruthenium and osmium, with from 4 to 20 per cent of iron, the manufacture of platinum and its alloys into their various products, require laboratory control at every step.

Without platinum crucibles and apparatus the science of chemistry would have been much more limited in the last one hundred years; it is used in great quantities as a catalyzer, as is the related palladium also. Alloys containing up to 30 per cent iridium are used in the platinum of commerce, where greater hardness is desired, as in the manufacture of contacts for magnetos used in gas engine ignition, hypodermic needles, jewelry, anti-cathodes in X-ray tubes, lightning rod tips, resistance thermometers, etc.

Women have as yet not entered the laboratories of the platinum industry. One manufacturing firm expressed through its secretary the judgment that much of the laboratory work could be

performed satisfactorily by women and that there would be no hesitation in employing women if conditions were such that they could work to advantage. "We have never employed any women in our laboratory thus far, the nature of our business being such that they could not perform all the work required, part of which consists of operating furnaces and handling molten metal."

One interesting position in the field of precious metals is that of a woman who is consulting chemist to jewelers. "I visit jewelry factories and other factories that handle the precious metals and there demonstrate methods of refining, melting, alloying, etc., the precious metals. I also give much instruction and advice by mail all over the world on subjects connected with the technique of the heavy metals, including electroplating, finishing, etc.

"Perhaps I am pessimistic regarding the profession of chemistry. But it is a fact that whatever success I have attained (and I am recognized as an expert in platinum) has been secured by my keeping my sex a secret. Most of my work as a consulting chemist was done by mail at first and I was known as Mr. ———. In many cases trouble and dissatisfaction arose when I went personally to a factory and introduced myself."

Rare Earths. The twenty or more elements bound up in what have been called "rare earths" have only in the last fifty years attained commercial use as a result of the development of the Welsbach burner; the chief sources of the material for these burners is monazite sand composed of phosphate of cerium and a small amount of thorium. The mantles must contain a large amount of thorium and a very small amount of cerium. Chemists have found other commercial uses for the surplus cerium, principally in lighters and sparklers.

In the refining and manufacturing of these metals, chemical analysis and testing control the processes, and chemical research has been essential in developing new products and new uses for them. A woman chemist with experience in this field writes:

"The monazite sand is refined in our plant. I analyze the product at different stages to determine the loss. I analyze the other rare earth products we sell to determine the cerium, titanium, or whatever the product is.

Radium. This is the metal of marvels which has brought glory to the history of women chemists; for not only is radium the wonderful substance which reveals sources of energy undreamed of, whose discovery has led to a new atomic theory, but this discovery,

also, the world owes to the brilliant woman chemist, Madame Curie, who worked patiently and under great difficulties for years before she could prove that such an element existed and for years more before she could isolate the metal. She has the honor of being the first woman to discover an element.

Now she is recognized as the "greatest living scientist" by the peers of science. Universities have hastened to honor themselves by conferring upon her their highest degrees. In announcing her unanimous election as an Honorary Fellow of the American Museum of Natural History its president said to her: "You are the first woman ever to receive this honor. It is given in recognition of your great discoveries in the field of physics, mineralogy and chemistry, and it is given with enthusiasm on account of the importance of those discoveries."

The United States now produces more radium than all the rest of the world together. Colorado and Utah have abundant deposits of the carnotite ore, but the process of manufacture is still a slow and costly one. There are 5 laboratories in which approximately 25 chemists are conducting research on the many problems associated with radium and its production. The industry will expand in proportion as these problems are solved.

Metal Products. In the manufacture of a large number of products which are constructed principally or entirely from metals, chemists are employed for the testing of materials used, for the development of new materials, and for research. There are found, for example, in establishments in which pipe and pipe fittings are manufactured, laboratories for the chemical analysis of iron and steel, for the study of corrosion, protective coatings of iron, special grey irons and other high carbon iron alloys, and such special problems as the application of the arc electric furnace to the production of malleable cast iron.

Problems of corrosion are of importance to the shipbuilding industry also, as are the improvement of the strength and homogeneity of non-ferrous alloys and the testing of a variety of materials.

Manufacturers of steam boilers and accessories are concerned with the development of refractory materials and the treatment of boiler feed water as well as the study of the embrittlement of steel, aluminum coating on steel, and the like.

Manufacturers of oxy-acetylene and thermit welding apparatus employ chemists for the analysis of materials, for the development

and perfection of the process, and for giving instruction concerning the apparatus and the use of the process.

Chemical laboratories for the analysis of carbon and special steels, ores, alloys, gas and other raw materials, for the standardization of specifications for raw materials and the improvement of products are found in plants manufacturing wire. Such plants are frequently incorporated as one unit in a metal manufacturing company.

Manufacturers of industrial apparatus, particularly of newer apparatus, frequently maintain research laboratories for studying the problems of their customers or prospective customers. For example, a machine company which produces among other products vacuum dryers, evaporators and industrial chemical apparatus, works out practical experiments on materials furnished by customers to determine in advance what can be done by means of certain apparatus.

A plant producing glass enameled steel equipment invites manufacturers who require containers which would by their nature have no effect on chemical activity, which would have all the advantages of durability inherent in a steel container with none of its chemical limitations, to submit their problems to its research laboratories.

Chemists in a plant manufacturing centrifugal machinery are working on the purifying of used oils, purifying crude and fuel oils, making emulsions, clarifying extracts, etc.

In a watch manufacturing company, chemists analyze materials used, investigate the properties of enamel for watch dials and study the properties of metals with relation to watch production.

Women have been employed as analytical chemists and assistant chemists in a company which manufactures razors, in a tool industry, and in a plant in which taps and dies and steel tools are made. An unlimited number of other products are manufactured chiefly from metals and their production depends usually upon chemical control analysis and is in many instances developed through chemical research—cooking utensils, cutlery, arms, hardware, etc.

The two most extensive industries in which metals are basic raw materials are the automobile industry and the manufacture of electrical apparatus and equipment. In the automobile industry the chemist is depended on to prevent the purchase or use of improper or inferior materials—iron, steel, non-ferrous alloys, paints, varnishes, dressings and enamels, etc. The automobile industry is interested in the solution of such chemical problems as the improvement of fuel and its more efficient utilization, the provision of more

reliable metals, lighter and more durable batteries, more durable roadways and streets.

Women have but little experience in the chemical laboratories of this industry. In one plant six women were employed during the war; they had no chemical training except such as was given them quickly in the plant and their employment was considered an emergency matter.

In the industries in which the many forms of electrical equipment—machinery, apparatus and supplies, are manufactured, the chemical laboratories are important for the analysis of materials—metals, carbon products, paper for telephone condensers, incandescent solids and luminous gases for lamps, and a large variety of related substances.

The range of materials which come into the laboratory of a plant manufacturing electrical apparatus is evident from the reports of women chemists in such laboratories:

"Analytical, chiefly, more on alloys than any other one thing, but a great variety—paints, soaps, insulating materials, lacquers, papers, asphalt, chemicals for acceptance. We do research in slack seasons; these come only occasionally."

(*Woman chemist in a large electric company.*)

"My work was entirely in the laboratory, analysis of materials used in lamps, coal used in various plants, lubricants, steel, tungsten, cement, shellac, etc. In this laboratory the variety was very great and as the laboratory was comparatively small it was not the deadly routine that exists in large organized laboratories. We had slack periods in which I was free to do any research that interested me. I was always free to work out my own methods, etc."

(*Woman assistant chemist in lamp works.*)

Advancement into production positions has not as yet been open to women:

"The company will not consider placing women in the chemical engineering department, although men from our laboratory have been transferred. . . . Employers are skeptical about putting women in untried positions."

(*Woman analytical chemist in a company manufacturing electrical equipment.*)

"As to advancement, the man has a better chance. The average man would be given an opportunity in the shop, where the woman would have to be extraordinary. Girls need to get somehow the kind of general knowledge that most men have, that is of materials

and construction. Men do not want to work under women, so it is hard for a woman to get out of the laboratory."

(*Woman chemist in an electrical manufacturing company.*)

Apart from the restriction to work in the laboratory, the success of women depends primarily upon their individual qualifications for the work. In one plant in which two women chemists were employed during the war, the chief chemist, while granting that women make very careful analysts, found them lacking in proper training, in initiative and responsibility, and was especially disturbed by their "inherent timidity and hypersensitiveness." The first woman in a similar laboratory left a better precedent. She writes:

"I came through the interest of the managing director of the company. The consulting chemist was opposed to having women in his laboratory but consented to give me a trial. When I left he said my position would always be open to me. I was at the head of the analytical laboratory in the sense of being responsible to the consulting chemist for all analyses made. I had two assistants (men), one a trained chemist, and one untrained to do the dirty work."

In the electrical industries women have had opportunity not only for analytical work but for important laboratory research, which is generally conceded to hold no limitations for them but in which their experience has as yet been scant. A physicist *and* chemist in a laboratory for electrical, physical and chemical research describes her work as very variable. "At present it is an attempt to apply X-rays to chemical analysis. But when one problem is solved another quite different one may be given. The prospects of advancement are good if I do good work, poor for mediocre work. Prejudice against women in this field has been largely overcome. There are few limitations except the hesitation any employer feels in pushing ahead an employee who may at any time leave to get married. That is, the risk is greater with women than with men."

A woman who is laboratory assistant in electrical research is working on problems of the lamp factory. "The work is not hard and is very interesting; it is so varied that it does not become tiresome. Coming in touch with scientific literature and scientific people makes one realize that the work is worth while."

"Chances are nearly the same when a woman shows herself capable of working *independently*. Too often women don't know how to go about it. Scientists are apt to be broad-minded and give women a fair chance. I cannot overemphasize the need for women to develop a knack at research as early in their training as possible,

for the tricks of the trade are learned only by experience and a worker who is helpless in a laboratory is not worth the room she takes up and will never inspire the respect of men chemists."

(*Woman research chemist on problems of physical chemistry in an electrical manufacturing company.*)

The director of research in one company has summed up his judgment of women in chemical work as follows:

"I myself believe that the limitations for women in the scientific work of the country are determined by the women and not by the work. In the case of men I have seen, within my day, and I am not quite fifty, the application of chemistry increase so steadily that there are now at least 15,000 chemists at work, when there were not as many hundred when I was a student. It seems to me that most of the work which they do could be done by women, but this will only be demonstrated by trained women being available and even pushing themselves forward a little. . . .

"If it were possible to tell you exactly what the advantages are for women in scientific lines, and, definitely, what the opportunities are, and, finally, what courses women should take to suitably prepare themselves, there would be almost no need for that quality in the future women scientists which is most necessary for their work. When it is possible to lay out a perfectly safe and well-charted course, there will also be plenty of incapable people in it. I would rather encourage those who can work with faith and trust in themselves when the probable outlook is even as clear as it must be to anyone.

"I should advise young women to take up scientific work where it is most interesting to them, just as I would advise young men, and while some of them might have difficulty in obtaining the positions they hoped for, the same is practically always true of men.

"We certainly must not expect the future to reproduce the conditions of the past. Our safest guess is that the number of scientifically trained chemists in this country will continue to increase, at the rate of between one and two a day, as it has for eight or ten years."

Paint, Oil, Varnish. Statistics from the census of manufactures for this group of materials are as follows:

	Number of Establishments			Value of Product		% of
	1919	1914	Increase	1919	1914	Increase
Paints	602	585	17	$255,656,000	$112,409,000	127.4
Oils (linseed).	26	25	1	120,638,000	44,883,000	168.8
Varnish	227	215	12	83,440,000	33,215,000	151.2

These industries draw their basic supplies from many sources, mainly but not entirely organic—lead, gums, oils, cellulose,[1] synthetic resins and coloring matter developed from coal-tar products;[2] because of this latter relation manufacturers of paints and varnishes may also be found producing insecticides, germicides, fungicides.

The situation in this group of industries in regard to chemistry is well reflected in the statements of a director of research who has varied experience in the field:

"As to the future demand for chemists in the paint and varnish industry, I think it is going to increase. Up to about 1898, the chemists in this field could probably be counted on the fingers of two hands, and the majority of them were either owners or financially interested and could therefore be classified in my opinion not as *chemists,* but as *men with chemical training.* Since that time the demand has been slowly increasing. The industry was conducted by rule of thumb methods and the chemist was used only for routine work on raw materials. The antagonism of the practical man towards the technically trained was very strong and there was not much of a future for the latter. Information was withheld from him. This feeling is slowly being overcome and undoubtedly the chemist will gradually step from pure laboratory work to factory superintendence.

"As to the adaptation of women to this field, I do not think any woman would care to go into the factory, owing to the heavy and dirty work. I have heard of one woman varnish maker, however, but she is an owner; I have been informed that she could make varnish as well as a man. The future of a woman chemist would be, in my opinion, in the purchasing end or that of technical correspondence, after a laboratory training.

"The outlook in chemistry for women is undoubtedly every bit as good as that for men, although I have had no experience with female help.

"The greatest problem for research today in the varnish industry is the finding of some substitute for the imported gums that are used, and are daily becoming more scarce and higher priced. The solution of this problem at present seems to lie in treating ordinary rosin, of which there is an abundant supply native to our own country, so as to act like the imported gums. This is now being done by treating rosin with glycerine, but the process is expensive, doubling and often tripling the price of the raw material. A cheap process

[1] See p. 66.
[2] See p. 93.

that any varnish maker could use without special apparatus would be welcome."

In one plant two women were taken on during the war for analytical work and have been retained. The future for them here is considered to lie in the possibility of promotion to the position of assistant chemist. Their analytical work is found equal to that of men in all respects.

In another plant three untrained women are employed as dyer's assistants. There is no prejudice against employing women as analytical chemists and for library work, but as operating chemists they would not be considered.

Petroleum. Petroleum refineries in the United States numbered 304 in 1919, 176 in 1914, as recorded in the census of manufactures. The increase in number of establishments was 128, a gain of 72.7 per cent, while the increase in value of output was 314.9 per cent, from $396,361,000 in 1914 to $1,644,684,00 in 1919.

A report prepared by the United States Bureau of Mines in 1917[1] indicates the importance of scientifically trained employees in this industry. The workers engaged in petroleum production were grouped as follows:

Administrators	392
Geologists	92
Drillers	405
Pump men	68
Transportation engineers	88
Chemists and refiners	769

"Crude oil is the refiners' raw product which is converted into marketable materials. Up to the introduction of the automobile on a large scale, crude oil has been distilled under two general processes, i.e., that of destructive distillation where the object was the production of the greatest possible amount of illuminating oil, with lubricating oils for machinery as by-products, and that of fractional distillation under which the main object is the production of the greatest quantity of high-grade lubricants, including cylinder stocks, and with the illuminating oils and gasolines as by-products. Under this process, the yield from Pennsylvania petroleum was 20 per cent to 25 per cent gasoline, 40 per cent illuminating oil of various grades, 17 per cent of stock from which neutral oils were made, and 18 per cent residuum, the balance loss. As indicated, the con-

[1] Albert Hill Fay, Preparedness Census, U. S. Bureau of Mines Technical Papers No. 179.

ditions were changed with the advent of the automobile. The motorist understands that his lubricating oil and his fuel both come from crude oil, and from casual observation about 10 per cent is required for the lubricants and 90 per cent for fuel. The usual motorist sees no use for any other product from petroleum, and consequently expects the refiner to convert the crude oil into 90 per cent fuel and 10 per cent lubricating oil, and this is now the problem of the refiner, which in the present state of the art cannot be accomplished. The problem, however, resolves itself into that of decomposing the many complex hydrocarbons which go to make up the various crude oils into carbon and hydrogen, and then to recombine these in such proportions as will make marketable products. In view of the great progress in chemistry, we dare not say this is impossible, and are rather inclined to forecast that some method will be devised under which molecules of the proper size will be made at will. This, however, is principally a refiner's product, and will have to be carried out in an experimental distilling plant. The actual running of these plants can hardly be compared with any grade of work to which women are accustomed, though the examination and classification of the products obtained are well within their sphere." *(Chief of the research staff in an oil company.)*

Women chemists have been employed in the oil industry. So far they have been engaged in the testing of oil or in laboratory research work which in several cases has involved considerable responsibility in the laboratory. Many of the problems that are studied have to be given a try-out in an experimental plant or in the distillery itself and, as in other industries, women have not shared in this sort of work.

"In my opinion, chemical work along petroleum lines is primarily work for which women are not suited for the following reasons:

1. In most cases it is necessary for the chemical investigators to work, not only in the laboratory but also in the plant in order that they may obtain first-hand information as to the actual difficulties encountered and the best means of applying suitable remedies. From the nature of a petroleum refinery, it is not a safe or suitable place for a woman.

2. It is frequently necessary for chemical labor in a petroleum refinery laboratory to work at night. It is obviously not desirable to have women working at night even in laboratories.

3. Most women in chemical work are over sensitive as

regards questioning their results or correcting their mistakes. Laboratory heads are too busy to handle chemical labor with kid-gloves and for this reason it has been experienced that the average woman is not able to accept a relation as a purely business one.

"On the other hand, there are two branches of chemical work in the petroleum industry where in large laboratories women have proved themselves entirely satisfactory, possibly superior to men, in some cases. These are:

1. Analytical work of a routine nature where accuracy is absolutely essential and where no particular ingenuity is required.

2. Control physical testing work and devising new methods of test; women seeking employment in this particular line should be well trained in general physics even at the expense of some of the more advanced chemical training.

"This company has, at the present time, about ten women employed on the laboratory staff, only one of whom is a college graduate with chemical training. This one has been in our employ for three years and has given satisfaction in both the two lines indicated as, in my opinion, open to women. We should be very sorry indeed to lose her services."

(*Chief chemist in a refining company which manufactures petroleum products.*)

"I am sure there are no inherent limitations for women chemists, and the outlook for work in this line as a vocation is purely up to the management having control of the laboratories which employ chemists. In analytical work, particularly routine methods, women are to be preferred to the usual men because of their accuracy and attention to details." (*Chief of research staff cited above.*)

"I believe that there will doubtless be a large future for chemists in petroleum work. I feel, however, that it is a field in which women will be somewhat handicapped because of the dangers and rough character of much of the work, the fact that women's mode of dress makes the fire hazard greater with them than with men, and the fact that the industry and its physical facilities have been built up on the basis of male employees only.

"These objections do not apply with great force to straight laboratory work, but it will be understood that in the petroleum industry at present the laboratory worker must often follow his discoveries into the manufacturing plant."

(*Manager of development department in a large oil company.*)

Photographic Materials. The census of manufactures reports 168 establishments producing photographic materials in 1919; since only 59 were reported in 1914, this represents a gain of 109, or 184.7 per cent. The gain in the value of the products was from $34,768,000 in 1914 to $110,332,000 in 1919.

The fact that cellulose is used as a basis for the production of films has been referred to.[1] Since important chemicals used in the manufacture of photographic materials are derived from coal-tar products,[2] this industry has played a large part in the recent domestication of the production of coal-tar products.

Although the number of laboratories connected with the establishments engaged in the manufacture of photographic materials is limited, their scope is extensive. This is illustrated by the following outline of the organization of one group of research laboratories in this industry:

1. Physical and colloid chemistry, where the lines of work have been defined as including investigations of the properties of gelatine in relation to the process of manufacture, composition, treatment, etc.; investigation of the properties of nitrocellulose and other cellulose derivations in solutions, films, etc.; photographic study of colloids; mechanical analysis of colloids and suspensions including photographic emulsions.

2. Analytical and inorganic chemistry, covering special analytical work of all kinds, but particularly silver salts and gelatine and analytical investigation of the chemistry of photographic processes.

3. Photographic theory, covering special physico-chemical investigations on the theory of photographic processes.

4. Techno-chemical and service department, covering technology of manufacturing processes, development of new materials, processes and testing methods, and service work for various divisions.

5. Photographic chemistry, including toning and tinting of motion picture film and lantern slides, preparation of photographic solutions, cause and removal of spots, marks and stains from film and plates, and miscellaneous problems.

6. Organic research department, dealing chiefly with the preparation of organic compounds, especially dyes and developing agents required for experimental work.

7. Department of synthetic chemistry for the preparation of chemicals for use in research.

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[1] See p. 66.
[2] See p. 93.

Women chemists have been employed in all of the laboratories of this industry. In the laboratories for synthetic organic chemistry a special limitation has arisen for women from the fact that the work is more than usually dangerous. An accident to one woman influenced a laboratory to discontinue taking on women chemists because disfigurement is considered a greater misfortune for women than for men. There is no evidence that this consideration has been a deterrent in the minds of the women themselves.

Rubber. The rubber industry is the fourth largest of American industries. Since the manufacture of rubber has been dependent for its raw material upon foreign sources, there is a constant incentive both for developing methods of using commercially gums other than rubber and for making synthetic rubber on a profitable basis. There is no danger of glutting the market with this valuable product, the uses of which multiply with its availability.

Various suggestions for new uses of rubber have resulted from the recent prize scheme of The Rubber Growers' Association, such as raw rubber soles for shoes, rubber for roads, rubber platforms in railway stations.[1]

The chemist has been of tremendous importance in the rubber industry from the time of Charles Goodyear's experimenting, which resulted in 1772 in the accidental discovery of vulcanization (the hardening of rubber when mixed with sulphur and heated); while this fundamental process has made rubber of such wonderful use, the details of it are not as yet known to the scientist. New compounds and new products have their inception in the laboratory, where the quality of materials used in the manufacturing process is also controlled. Organic and physical (particularly colloid) chemistry are the special lines chiefly involved in the rubber industry.

There is agreement among those who know the industry as to the future need for chemists in the manufacture of rubber.

"There is bound to be an increasing demand for chemists, as it has only been in the past few years that the many important problems of the rubber business have been scientifically attacked. The technical training for this business should include chemical engineering and thorough courses in mechanics and physics."

(Chief chemist in a company manufacturing mechanical rubber goods.)

"It is our opinion that the future demand for chemists in the

[1] See Chemical Age, December, 1921.

rubber business will be considerably greater than at present, particularly in the case of tire manufacturing concerns."

(General superintendent of a rubber company.)

"As to the future demand for chemists in the rubber industry, there can be but one answer. The industry is one in which the services of chemists are indispensable. In fact, the chemist does now and doubtless always will dominate the rubber field."

(Chemist in the research division of a tire and rubber company.)

There are many and varied development and research problems before this industry. "What is most needed is a thorough understanding of the fundamental operations, such as the standardization and thorough testing of the raw products and their relationship to one another, also a knowledge and control of vulcanization. When these things are accomplished, we will have done much toward the greater success of our business."

(Chief chemist in a rubber company.)

A few of the problems at present pertinent to rubber production, as stated by chemists in the industry, may be summarized as follows:

1. The mechanism of vulcanization.
2. The polymerization and depolymerization of rubber.
3. The development of accelerated aging tests for rubber stocks.
4. The effect of temperature and manipulation time on hysteresis; heat control on mixing mills and calenders.
5. The determination of stress-strain curves for different temperatures.
6. The causes of grain in rubber.
7. A study of the requirements of fabric for the tire and mechanical goods industry. A rubber factory uses about as much cotton fabric as it does rubber and the success of a tire, belt or piece of hose depends largely upon the proper selection of fabric used in its make-up. This problem covers a vast field and there are endless opportunities for research work.
8. A study of compounding materials and their effect upon the structure of the rubber compound. Microscopic studies would be of great value.

The development of organic compounds for special use in rubber manufacture is a recent important contribution to this industry. A number of laboratories are engaged in the study of various organic derivatives, and synthetic organic oils, waxes and solvents are produced in separate industries for the rubber business.

The manufacture of synthetic rubber on a commercial scale is still a problem of the future. It is a subject of research in various laboratories.

In the rubber industry women have to date only a limited experience; it is for them really a new field in which their slight experience gives promise of a good future even though the idea of employing women chemists is summarily dealt with by some employers who have not yet made the experiment.

"We have never employed women chemists and in all probability, on account of the nature of our work, never shall. We recruit material for the factory from the laboratory and therefore use this department as a training school in some degree."

(Director of laboratories in a rubber company.)

"We do not care to employ women chemists for the reason that there is not sufficient work of the nature best suited to women in our laboratory." *(Chief chemist in a rubber company.)*

"In general I would say that I do not believe it would be possible for us to use women in this work, as I consider it necessary for the chemists to take a course in the shop. This course requires the actual working of the material and, I believe, would be too severe a physical strain for women to undertake."

(Mechanical engineer in a hard rubber company in which a chemical laboratory has only recently been started.)

Employers in the rubber industry who have had experience with women chemists have been satisfied with their services and, in general, have faith in their future.

"There is no inherent reason why women chemists should not be as successful in the rubber industry as in any other. In my opinion, the chief fault with women chemists today is a deficiency in originality. I believe this is due largely to a lack of adequate training." *(Research chemist in a rubber company.)*

"Our experience with women chemists has been entirely satisfactory. During the war period they were employed both in the works laboratories and in research. The only limitations in the rubber industry as far as women chemists might be concerned would be such as are found in most other industries, viz., that their efforts would be confined to either the research or the works laboratories, it being generally considered that it is not desirable for them to contact directly in the works, and it is also probable, for some years at least, that they will not occupy executive positions."

(Development manager in a company manufacturing rubber goods.)

"We do not believe that there are any inherent limitations in rubber chemistry for women chemists. In fact, it would be our opinion that the rubber laboratory is admirably suited for women chemists. In this we make a distinction between the rubber laboratory and the general works laboratory of the metal trades. The latter is very often carried on under conditions which would make it undesirable for women.

"Our own particular laboratory is quite small, employing but four, the chief chemist and three assistants. Our work is confined largely to general analysis and control, with possibly thirty or forty per cent of the time spent upon either general or scientific research. Our problems in this regard are mainly confined to investigations of the vulcanization processes and physical chemistry of raw rubber." *(General superintendent in a rubber company.)*

"We have employed several women chemists and have always found them willing, and more neat and orderly than the average man. Their limitations come, however, when it is necessary to develop a certain process in the factory. It is often necessary for a laboratory man to operate very heavy mills and calenders or work under very hard conditions. For direct laboratory research work, we see no reason why a woman should not succeed equally as well as a man, provided, of course, that she is willing to make the profession her life work."

(Chief chemist in a company manufacturing mechanical rubber goods.)

"Our chemical staff is divided into two parts: laboratory chemists composed of analytical and research men, and plant chemists who have worked their way through the laboratory and have become responsible for the chemical control of the manufacturing operations of various departments. Due to the nature of the work, the positions for women are only open in the laboratory.

"Our chemical work is not rigidly divided into routine and research for the reason that our routine is quite varied and irregular and very often allows time for research work besides. . . . We are trying every possible way to take deadening routine away from our laboratory workers, to leave them free to pursue original lines." *(Chief chemist in a rubber company.)*

One woman who is research assistant in a rubber plant is engaged in the special problem of the study of accurate methods of determining the constituents of waste and reclaimed rubber, the complete analysis of such rubbers and experimentation on a laboratory scale in new methods of reclaiming rubber. Her experience leads her to

the conclusion that women are not yet competitors with men in the chemical field. "There are still too few of them and the average of ability is not yet nearly so high. I do not think men in upper positions now oppose women's advancement if they can show fitness. Young men with whom they come in competition may do so."

Soap. The extent of the soap industry in the United States is indicated by the figures of the census of manufactures which records 352 establishments engaged in soap making in 1919, 371 in 1914. The value of the soap produced in 1919 was $317,067,000, an increase of 147.7 per cent over the value of the product in 1914, $127,942,000.

The manufacture of soap is a chemical process and must be controlled by chemists. Raw materials—oils, fats, alkalis, and others, are analyzed not only for control of quality, but also for regulation of price. The finished product is analyzed in order to standardize the quality and maintain uniformity. Various chemical problems arise in improving the processes and in developing new products. It was a soap manufacturing company, for example, which first successfully hydrogenated oils and offered the hardened fat as a commercial substitute for lard.

Soap making depends upon a knowledge of the laws of general and physical (especially colloid) chemistry.

Among the objects of research of present interest in this industry may be mentioned:

1. A better knowledge of the detergent action of soap, an extremely complex problem on which considerable diversity of opinion exists.

2. The possibility of making synthetic fats or fatty acids from petroleum products like vaseline.

3. The development of an efficient and cheap non-metallic catalyzer for use in the hardening of oils by hydrogenation.

"I believe that women chemists with suitable fundamental chemical training and a natural aptitude for research work could satisfactorily fill positions in a research laboratory. For women chemists of less extensive chemical training than is required of a research chemist, positions of a purely laboratory nature would be open in a plant control laboratory. In my opinion, however, a position as a plant control chemist which would require cooperation and contact with the men in a manufacturing department would be a difficult and impractical position for a woman chemist owing to the prejudice which exists among non-technical men against a woman in a technical position.

"It appears to me that the value of chemists to the industry was so well demonstrated during the war period that there is bound to be an expansion of the application of chemistry to industry as soon as the present stringent economic situation is relieved and that in this expansion there will be opportunities for women chemists."

(Chemist in charge of general research laboratory in a soap company.)

During the war women chemists were employed in small numbers in various soap factories. As in other industries, their experience has so far only been in the laboratory.

"We have found that a thoroughly trained woman chemist is as satisfactory as a man for straight analytical work. She is not adapted for research work which requires actual plant operation."

(Chief chemist in a soap manufacturing company.)

In a plant where an untrained and a trained woman were taken on in the analytical laboratory, the trained woman was the one to be kept when the staff was reduced; her work is described by the chief chemist as very satisfactory.

One woman chemist in a soap company describes her duties as "routine and control work. At first I ran iodine values on fats and oils, on liquid fatty acids; free fatty acid tests; moistures; acetyl values. Then I ran total fatty acids on soap stock; percentage of glycerine in soap stock; saponification values; nickel in liquids, lards and muds; sulfates; tars; copras and some odds and ends. When regular work is slack one can do about as he pleases with the materials on hand. However, the routine work generally keeps one busy.

"The work is rather dirty and if the men did not help would sometimes be too heavy for women. In our particular plant the women are handicapped because the research chemists must go into the factory and try out their experiments under actual running conditions. The work is considered too dirty and heavy for women. The best opportunities for women are to be found in the laboratories of large industrial concerns, where the men can take over the heavier work."

An analytical chemist in another soap factory is in charge of the laboratory force. In this laboratory each girl or group of girls is trained to become particularly efficient in one phase of the analysis. Three samples of raw materials are submitted, one for immediate use, one for reserve in case of accident or other emergency; the third is the official sample, which is sent to a consulting chemist,

a neutral party, in case of a dispute as to the cost price between the seller of the material and the buyers.

Textiles. "Textile chemistry" covers the chemical problems involved in the manufacture and testing of textiles; these include chiefly the chemical composition and properties of fibers, vegetable, animal and artificial; dyes and the dyeing of various textiles; bleaching of cotton and linen; scouring, bleaching and felting of wool; carbonizing; silk scouring and bleaching; the action of soap; water and its application in the textile industry.

In textile laboratories such problems as the fiber content of samples of raw material, the strength and wearing qualities of fabrics, the resistance of dyes to light, bleach, stains and washing are studied, while all coal, oils and soaps used by the mills are also tested.

While the "textile chemist" must, therefore, be well versed in general chemistry, organic chemistry is the field in which the largest number and the most important of the textile problems lie.

The chemist in charge of the research staff in one plant finds that the greatest problems confronting the textile chemist are those connected with the application of dyestuffs to the various fibers in such a way as to control the evenness and the tone or shade of the coloring. The following examples of problems are cited:

To color a 1200 pound batch of loose cotton, compressed into a mass of 7 feet in diameter by 3 feet deep, pump the dye through it so that the top, middle and bottom shall all be alike in color.

To color 24 pieces of 54 inch worsted dress goods in the same kettle at the same time so that the pieces shall all be alike and each piece be the same shade side to side, side to center, and end to end.

There is considerable opportunity for research in this field and some indication that there will be an increasing demand for scientific testing of fabrics for the protection of the consumer. This is evident in the recent movement to provide government control over the standards of fabrics. Such demand will inevitably increase the employment of chemists by textile manufacturers and merchants.

Textile chemists are employed not only by manufacturers of textiles, and by manufacturers of materials used in the making of textiles—bleaches, finishes, dyes, oils, soaps, etc., but also by manufacturers of clothing and by wholesale and retail merchants who deal in fabrics and articles made from them. Textile chemists are also engaged in solving laundry problems—improved methods of cleaning and removing stains, reasons for injuries to fabrics, etc.

Alice Wakefield of Mellon Institute is a woman chemist who has done much valuable work in this field.

An incident illustrating the relation of the chemist to the clothing industry occurred in a large company which manufactures shirtwaists and aprons. "The sewing of these garments was accomplished by high speed machines lubricated with a thin water-white oil; occasionally a drop of oil, flicked from the machine, would light upon a garment to remain undetected in the final inspection. But six months later when the goods were on sale in some store, these spots, rendered prominent by the coloration of the oil, due to its oxidation, rendered the garments unsalable. Though the company was entirely willing to replace the soiled garments, it was anxious to avoid this trouble and expense. One solution of the problem would have been a more careful final inspection. But the chemist aimed to make the spots more easily detected, and to this end he sought for a dye to put into the oil. The difficulties which he experienced in finding a dye which would dissolve in the oil, which would not interfere with the lubricating properties of the oil and which would wash out easily, were quite numerous, but he finally found a red dye which fulfilled all requirements and replacements became almost negligible."[1]

Elizabeth Weirick is in charge of the Textile Testing and Research division of the Technical Laboratories of Sears and Roebuck. The work of this division includes the chemical and physical testing by fabric analysts and textile chemists of merchandise—artificial silk to identify it and to determine the amount of "loading," muslin sheets for over-bleaching, and the like. Textile testing includes also microscopic analysis, the counting of threads and silk twists, for example.

Since textiles are of fundamental interest to women as consumers, this field has been deemed of special fitness for the woman chemist. Manufacturers of textiles have to some extent employed women for analytical, experimental and research work and it is in general considered that there are no inherent limitations for women as textile chemists except possibly in connection with plant processes. A woman chemist in a textile mill laboratory writes of this factor as follows:

"In a factory a man who is in charge of the chemical laboratory has the opportunity to go about the plant and learn in a practical way each branch of the technical side of the business; eventually he may become general manager of the works. A woman reaches the limit as head of the chemical laboratory. It is in my work

[1] Industrial Management, December, 1921.

here that the question of permanency was called to my attention. A man works up, proves his value to a plant and it is more economical to keep him at constantly increasing salary than it would be to break in a new person. A woman works to a point of being of real value and lo and behold (*they say*) she suddenly departs. Now as a matter of fact I wonder just how many times it is marriage which takes her from her profession and how often it is not that some more progressive concern offers her more nearly what she is worth. This very factory has just lost its head laboratory chemist (a woman), largely because the management could not see that the market value of a woman chemist is somewhat higher than that of a stenographer. At the time when a general increase in wages became effective throughout the works, this woman chemist was entirely left out because she was already receiving so much more than stenographers' wages. And then when she gave her two weeks' notice she was told she was not acting like a man.

"I have just been offered the position of 'boss chemist' with a considerable raise in salary, but upon careful consideration of every aspect of the proposition I have deemed it wisest to refuse. The salary is not attractive enough to make me willing to sign a three-year contract (with three months' notice if I should plan to leave). The management is not conducive to the best sort of work." When the head laboratory chemist was replaced by a man, the same witness reported that since the arrival of the new chief the work has been far more interesting—"All of which makes me feel more and more that the *head* chemist in any sort of industrial plant should be a man. No matter how clever and efficient a woman may be she cannot get about in the works and mingle with the workmen and machinery to a great enough extent to put the live touch into the laboratory work—to give it zest."

The matter hinges on the question whether or not women can "get about in the works and mingle with the workmen and machinery." Women have not done this to any great extent, but there are undoubtedly some women with the ability to do it, especially in industries which employ large numbers of women operatives as do the textile and clothing industries. Tradition will only be overcome through the demonstrations of such ability, disposition and initiative by women who have the requisite technical training and experience.

A woman chemist in another textile mill finds that there is a decided indisposition on the part of many mill men to let a woman wander as freely in the works as do the men. "Much of this is due to prejudice. Every woman going into a field where there are but

few women workers will meet some unfairness and discrimination in favor of the men, which, as she proves her value and is a 'good sport,' not disagreeable, wears off. I do not mean 'good sport' in any degrading sense, but in the seeing that women have to stay right at the job and smile and not be hurt or at least show any hurt, if there is injustice, because if she knows what is of value to her concern she will in due time have recognition."

In a plant producing one special fabric a woman chemist is in charge of dyestuffs and water. All samples of dyestuffs submitted and shipments of dyestuffs used are tested; problems in dyeing are worked out; the water used for dyeing is analyzed daily. Although she describes her work as dirty, often hard and in some cases rather dangerous, she considers chemistry one of the best vocations open to women and sees no limit to the progress possible for one who is devoting herself wholeheartedly to her work—"making your employer's business your business and his interests yours."

A chemist in a plant manufacturing among other things bleaches used in the textile industry is occupied in solving problems submitted by customers of her company. "The chemist is really assistant superintendent of the bleaching station with a laboratory assistant for small sample work and a bleacher with laborers to handle larger lots in the model bleachery."[1]

Wood Products. The extent of the lumber industry in the United States is very great. Far less extensive, but more important for the chemist, has been the commercial development of wood products. The statistics from the census of manufactures are:

	Number of Establishments			Value of Products		% of
	1919	1914	Increase	1919	1914	Increase
Lumber and timber products	25,794	27,229	—1435	$1,400,000,000	$715,310,000	95.7
Wood preserving	88	68	20	32,521,000	21,055,000	54.4
Wood distillation	113	95	18	31,827,000	9,883,000	222.

For many years engineers and chemists have been endeavoring to devise means to use the enormous waste incident to the cutting of trees for lumber. "The lumberman wastes two-thirds of every tree he cuts down. The rest is left in the forest as stump and tops or thrown out at the mill as sawdust and slabs. The slabs and other scraps may be used as fuel or worked up into small wood

[1] See also p. 4.

articles like laths and clothespins. The sawdust is burned or left to rot."[1]

As a result of long experimentation destructive distillation of trash wood now produces tar, pitch and charcoal, gas, crude wood alcohol, crude acetate of lime; by the sulphate process waste wood can now be used as raw material for pulp and paper. These processes in utilizing waste have only recently been put on a commercial basis. While the industry is still relatively small, there will be a certain and probably increased demand for chemists in this line.[2]

The chief chemist of a wood products company comments that there is nothing about his laboratory which could not be done by a woman chemist, but adds: "The only advantage men would have over women is the fact that in our plant we recruit our department heads in the manufacturing department largely from the laboratory. This plant work usually would not be well suited for women thus limiting them to laboratory work permanently."

Miscellaneous. Industrial establishments which are not primarily manufacturing plants, particularly public utility corporations and railroads, also require extensive laboratories for control of the many materials which enter into their service, and for the development of new and better equipment and processes.

In the laboratories of one railroad company, for example, approximately fifty chemists are employed. In these laboratories are developed methods for the determination of elements in plain carbon steels, alloy steels and non-ferrous alloys; fuels are examined; specifications are made for paint products; boiler compounds, lubricating and burning oils, lacquers, cleaners, polishing compounds, belt dressing, fire extinguishing preparations, the recovery of used or waste products are all subjects of analysis and study.

The laboratories connected with telephone systems are concerned with the development of new forms and the improvement of existing forms of apparatus and equipment for electrical communication. Water supply companies study the filtration and softening of water for public use. Gas companies maintain laboratories for control and for the study of problems consequent to the manufacture, purification and distribution of illuminating gas, and the manufacture of synthetic chemicals. Electric power companies employ chemists for the study of problems in better generation, distribution and utilization of electricity.

[1] Creative Chemistry, p. 126.
[2] See also p. 170.

Construction companies also have laboratories for the testing and the study of cement, concrete, timber, corrosion of iron and steel, preservative coatings for wood and metal, paints, putty and innumerable supplies.

INDEPENDENT LABORATORIES

Independent laboratories have accomplished important pioneer work in demonstrating to industry the practical value of scientific control and research, and of replacing rule of thumb methods by newer ones based upon scientific knowledge and study. Some of the most valuable research in chemistry as related to industry has been and is today carried on in independent laboratories. These laboratories are often particularly valuable to smaller industries which are not in a position to maintain their own research work.

Independent laboratories may be classified into two groups, those maintained by trade associations or groups of industries and those which are entirely independent enterprises maintained by chemists themselves. The former are in a position to study problems of universal interest to the industry represented in the association and to offer consultation service for the solution of particular problems of individual member companies.

The consulting chemist, who is established separately from the industry he serves, is in a position to attack particular problems entirely without prejudice and with a background of experience gained from contact with a large variety of industrial establishments.

Laboratories of Trade Associations. To a limited but increasing extent trade associations are maintaining laboratories for the service of their member companies. Such associations may be chiefly concerned with control work, as is true, for example, in the laboratory or inspection department of associated fire insurance companies.

"The work of our chemical department includes research to ascertain the inherent hazards of various products and to obtain data as a basis for standard specifications. The subjects embraced in this work include propagation of flame arresters, explosion pressures, ignition temperatures, and so on. This relates to such materials as rubber (used for fire hose and electrical insulation), fire extinguishing solutions, nitrocellulose, etc."

(*Chemist in laboratories maintained by a board of fire underwriters.*)

"These laboratories are maintained for investigating all matters relating to fire protection engineering: tests of fire extinguish-

ing apparatus, which involve detailed laboratory examination and operating performance of automatic sprinklers, fire pumps, hydrants, valves, hose, chemical extinguishers, etc., calling for mechanical, hydraulic and chemical engineers; studies of manufacturing processes with a view to reducing fire hazards, methods for safely storing and handling inflammable liquids and materials, etc. It is in this branch that the chemical engineers are most helpful. Much of the routine work is performed in the field as well as in the laboratories."

(*Director of laboratories of associated factory fire insurance companies.*)

The director of one of these laboratories feels that the test work is of too heavy a character to be performed by women; yet in a similar laboratory women were employed during the war. Their director is not prejudiced against women by his experience. He writes: "At the present time we are not employing women in chemistry. We did during the war. Whether we will or not in the future very likely depends upon the qualifications of future applicants."

There are instances, like the Silk Association of America, of trade associations which have selected a consulting chemist, or a testing company or a company of engineers as the official testing house for the association.

The development and research work of trade association laboratories is illustrated in the following excerpts from descriptions of their service:

"The Exchange Research Laboratory is a part of the California Fruit Growers' Exchange. Our service to the members of the Exchange is collective rather than individual; that is, we work on problems that affect the entire citrus industry. The principal work so far, as well as that contemplated, has to do with the development of satisfactory methods of utilizing the low grade fruit. This work naturally develops along the line of the manufacture of various products from citrus fruits which can be marketed so as to bring a satisfactory return to the fruit growers.

"The Research Laboratory also handles questions of a chemical nature, relating to the effects of various practices in the production, packing and transportation of citrus fruits. Our work is largely laboratory work, but involves some field work, and some work in the factories making such products as citric acid, lemon oil, orange oil, orange vinegar, dried orange peel, etc.

"Three chemists comprise the staff of the Research Laboratory. Probably two-thirds of our work could be performed by women as well as men. We now employ one woman chemist."

"The American Institute of Baking is the scientific department of the American Bakers' Association; it operates research and service laboratories and will shortly open a school for the training of bakers. It is difficult to outline the research problems commanding our attention. In our own laboratories we are working on a dozen lines of fundamental interest to the baker and we are studying flour types with a view of obtaining the basic facts which determine the quality of flour. We are studying the control of fermentation. . . . The work of the Institute is chiefly laboratory work at present, although our investigations are carried direct to the plant after they have passed the experimental stage.

"We are now carrying a director, assistant director, chief chemist and assistant chemist. We shall shortly have a biological chemist, an expert in nutrition and a chemical engineer, and when we open the school of baking we shall have several other chemists and bacteriologists who will do some teaching in connection with their routine work."

The National Canners' Association maintains a central research laboratory to study a wide range of food problems[1] which closely concern its members. This laboratory is described as "a small one relatively speaking. Our work is of a peculiar nature in that much of our experimental work must be done in the field and involves traveling under conditions to which women would not be adapted. On this account we prefer men because after receiving some preliminary training in the laboratory they are available for a kind of field work for which a woman would not be suited.

"We have one woman on our staff who is giving entire satisfaction in the work of the laboratory and who, I think, feels no sense of injustice that she cannot look forward to field work mentioned above. . . .

"One of the important things I think for a young woman to remember starting out in such a field is that she must feel herself on a par with others and in the usual laboratory life must expect only the courtesies extended to a man in the same position."

Trade associations, like individual industries, frequently cooperate with educational institutions in research work. For example, the Portland Cement Association maintains with Lewis Institute a Structural Materials Research Laboratory in which chemists as well as engineers and physicists are engaged in studying a variety of problems in cement and concrete. The Tanners' Council has established research work in the department of chemistry at the University of Cincinnati. Several of the fellowships at Mellon In-

[1] See p. 102.

stitute are supported by trade associations. The experiment station of the Hawaiian Sugar Planters' Association cooperates closely with the College of Hawaii.[1]

Groups of industries not organized as a trade association have in some instances established laboratories for their common use; as, for example, the Independent Oil Testers' Association; or the New York Sugar Trade Laboratory, a neutral control laboratory for checking up differences in findings between the chemist of the seller and the chemist of the buyer of raw sugar as to the percentage of sucrose, upon which the price depends.

Consulting Chemists. Consulting chemists or advisory chemists usually maintain independent business establishments with their own laboratories. They serve individual industries upon call by testing, analyzing, making plant investigations offering constructive development plans or undertaking specific research problems either in their own laboratories or in those of the industry concerned. Their work may be entirely chemical or may include also engineering advice and research. Often the title assumed by a firm of consulting chemists emphasizes this latter service—consulting engineer, engineering specialist, chemists and engineers, or chemists, engineers and managers. Sometimes the title emphasizes the fact that the service of a consulting chemist or firm of chemists is primarily testing—testing company, or testing laboratory. Still other firms incorporate in their names the suggestion of a very wide service—laboratories of applied chemistry; industrial research laboratories, general consulting and research chemists, resource and chemical engineers; industrial research laboratory, consulting chemists and engineers, plant design and construction; analytical and construction chemists, research in technical processes, advice and appearance in litigated matters.

Almost every firm of consulting chemists must limit its activities to certain fields. There are those who are primarily assayers and metallurgists, or wheat and flour testers, or specialists in boiler feed water treatment, textile fibres and dyestuffs, etc. There is specialization particularly in the research work carried on by consulting chemists. One firm, for example, is studying milk pasteurization, sanitation, corrosion, destructive distillation, and paints and dryers; another, electrochemical and organic problems; still others, agricultural problems—milk and food or nitrates and fertilizers. One firm specializes in problems of drying and dessication of foods. Chemical and photomicrographical problems as applied

[1] See p. 110.

to criminal investigations; petrol and vegetable oils, electrometallurgy of rare elements; tanning materials, leather and leather products; rubber, textiles and allied materials; industrial gases—these are among the groups of subjects in which independent chemists are conducting research.

Civil engineers may include chemists and bacteriologists on their staff, particularly for water analysis and the control and study of matters pertaining to water supply, chemicals for filtration, etc. Contractors who build water filtration plants employ chemists, upon whose analyses the treatment of water in varying situations is based.

No record has been found in the course of this study of any women consulting chemists who serve industry. There are, however, a few instances of women who have established independent laboratories for other purposes. Private laboratories for clinical analysis, operated by women chemists, have been referred to.[1] In order to follow her own interest in chemistry in conducting independent research, Dr. Fanny Hitchcock has erected and equipped a laboratory in Philadelphia which is provided with the very best and most complete instruments for investigation in physical chemistry. She has published some important results of her research.

A number of women have been employed in the laboratories of consulting chemists. An analytical chemist in an "industrial chemical institute" finds her work quite varied in connection with her firm's "analysis of raw materials and finished products for all industries, solving of manufacturers' problems, utilization of waste products, etc.," although her own analyses have been mainly of food materials and food products. She finds opportunity for constant mental growth and development in the association with big minds and also in the constant contact with the latest books on chemical subjects.

In the office of a civil engineering firm a woman chemist handles all routine bacteriological as well as chemical work. "Most of this is water analysis and things pertaining to water supplies, as chemicals for filtration, etc. Also I handle all operation reports and charts telling of chemicals used. If anything is wrong in this line I make an investigation to get at the bottom of the trouble. At present I am doing some bacteriological research."

In one laboratory of consulting chemists women have been employed for approximately fifteen years. Although their number has been small, the chief chemist can base his judgment of them

[1] See p. 43.

upon an experience covering a fairer period of time than that of women's experience in most industrial laboratories, and it is not surprising to find sex distinctions eliminated: "They vary in efficiency about as men do. It will be possible for them to advance to be chief of the laboratory—same opportunity as men. There is no specific salary limit, $3000 to $5000, in special cases more. There is no definite starting salary, this depends on the individual and the previous experience."

In one laboratory which took on two women during the war, and in which five have been employed at various times since then, the experience has been unsatisfactory. Women are considered to be "not willing to use their own judgment and go ahead with new work; unable to increase normal speed or capacity when necessity arises, or to handle successfully more than one type of analysis at one time."

A firm of consulting engineers which at different times has employed three women, points out one traditional difficulty which women meet here as elsewhere. "All of these women gave us excellent service. They were conscientious, careful, agreeable and obliging, but as the result of our experience, I do not believe that I would hire any more except for purely laboratory work. Not that we would have any doubts about their competency, but our clients looked askance when we sent a woman to collect samples. It is hard for them to believe that the woman comes on a serious errand. One of our assistants used to complain bitterly that she was treated as a woman and not as a chemist.

"Then again our work requires a great deal of rough work—all day sampling tours in paper mills, factories, bleacheries, etc., and the problem of sending out and caring for a girl in the field under present social conditions is more or less difficult."

Several consulting chemists have expressed the point of view which is succinctly summarized by one of them as follows:

"First, the demand for chemists and chemical engineers will, in my opinion, be several fold greater in the future than it has been in the past in this country.

"Second, in laboratory and research work and in plant control I do not see any inherent limitations for women.

"Third, I believe the outlook in chemistry as a vocation for women is bright, but that the success in each particular case must, as in all professions, depend upon the aptitude of the person and her interest in her vocation."

IN GOVERNMENT LABORATORIES

The public service offers chemists a variety of opportunities for a career in federal and state and some municipal government departments. There is also reason to expect improved conditions of work and opportunity for progress in the future; Congress has under consideration a measure[1] for bringing about a comprehensive classification of the civilian employees of the Government for the purpose of equalizing and standardizing compensation and providing for a uniform and equitable system of promotions. In state and city governments there is also interest in reforming the civil service regulations so as to insure better recognition of able service.

In November, 1919, the Federal Civil Service Commission ruled that women may enter all examinations equally with men. Departments may, however, still exercise sex preference in the selection of appointees from the eligible list, and there is much discrimination in favor of men. The measure now before Congress would establish the principle of equal compensation for equal work; this would be one further step in the elimination of sex discrimination.

FEDERAL GOVERNMENT DEPARTMENTS

Experience in a number of the federal bureaus is considered admirable training for scientific work. The Bureau of Standards covers a wide field of work in physics, chemistry, engineering and industrial technology, including research and standardization. The opportunities for research are excellent, although experimental testing usually forms the major part of the work of new appointees. The close connection with the industries makes experience in the Bureau particularly valuable as training in industrial research. The staff meets weekly and cooperative study courses are conducted by its members which are accepted by several universities as credits toward a higher degree. The Bureau has a highly specialized library of 18,000 volumes and the free use of the other scientific collections in Washington.

The Department of Agriculture has also inaugurated a system of advanced instruction in scientific and technical subjects related to the work of the department. Among the courses given are

[1] The Lehlbach Bill, passed by the House of Representatives, December 15, 1921, and now under consideration by the Senate.

included biochemistry and statistical mechanics applied to chemical problems.

In 1916 there were 716 chemists and allied workers in the service of the United States Government under 71 distinctive titles.[1] Recent reports from Departments indicate that the present number is 1,198. The proportion of women scientific workers is still small. Great confusion exists in regard to the titles now applied to similar positions in various bureaus, and the need for reclassification of positions is generally acknowledged.

The following brief summary of the information concerning vacancies in chemistry and allied work for which Civil Service examinations were held in the years 1920 and 1921 illustrates the kinds of openings and the variety in their departmental and geographic distribution; it also serves to indicate the wide range of duties in the scientific work of the Government and the requirements necessary for entrance to the various positions in chemistry.

[1] Frederick E. Breithut, The Status and Compensation of the Chemist in Public Service, Journal of Industrial and Engineering Chemistry, January, 1917.

Positions in Chemistry for Which Federal Civil Service Examinations Were Held

1920

Title	Location	Requirements	Salary[1]
Laboratory Assistant	Bureau of Standards, Washington or elsewhere	College graduation with major in optional subject —chemical engineering, paper technology, textile technology, ceramics, physics and chemistry	$1200—1380
Laboratory Assistants	Bureau of Mines, Pittsburgh, Pa.	At least one year of college, including general chemistry and physics. More for higher salaried positions	$1080—1500
Ceramic Assistant	Ceramic Experiment Station of Bureau of Mines, Columbus, Ohio, and similar vacancies elsewhere	Graduation from a course in ceramics or ceramic engineering	$1200—1800
Analyst	Bureau of Mines, Pittsburgh, Pa., and similar vacancies elsewhere	High school graduation plus three years of analytical experience in a chemical laboratory; or three years of college	$1200—1500
Scientific Assistants	Lighthouse Service, Tompkinsville, N. Y., and similar vacancies elsewhere	Familiarity with general photography; the equivalent of three years in a scientific or technical school, or high school plus two years of experience in a chemical or scientific laboratory or equivalent experience	$1500—$2400

[1] Employees who receive not more than $2500 a year may also be allowed the increase of $20 a month granted by Congress.

Positions in Chemistry for Which Federal Civil Service Examinations Were Held

1920—(Continued)

Title	Location	Requirements	Salary
Assistant Technologist	Bureau of Standards, Washington and elsewhere	College training, including the fundamentals of chemistry, mathematics and engineering or physics, plus at least one year of industrial experience in rubber, leather, paper, textile, oil or general technology	$1400—1800
Associate Technologist			$2000—2800
Associate Chemist	Chemical Warfare Service, Edgewood Arsenal, Md.	Ph.D. degree or equivalent, with major in one of several specified lines of chemistry. The applicant for the position of chemist must in addition have had two years of experience in research or industrial chemical work	$2000—3000
Chemist			$3000—4000
Assistant Explosives Chemist	Bureau of Mines, Pittsburgh, Pa., and similar vacancies elsewhere	Ph.D. degree or an equivalent, with major work in physical chemistry, organic chemistry or inorganic chemistry	$2400—3000
Assistant Metallurgical Chemist	U. S. Naval Ordnance Plant, South Charleston, W. Va., and similar vacancies elsewhere	At least one year of laboratory training in metals acquired in schools or other laboratories plus at lease three months' experience in the chemical analysis of steel and iron. Ability to make quick test analysis of steel for carbon, silicon, manganese, sulphur, phosphorus, nickel and chromium	$5.12 a day
Metallurgical Chemist	U. S. Naval Ordnance Plant, South Charleston, W. Va., and similar vacancies elsewhere	A college degree plus at least four years of experience in the analysis of steel; also steel-works analyses in general, including refractories, oil, fuel and non-ferrous alloys	$6.88 a day

Positions in Chemistry for Which Federal Civil Service Examinations Were Held

1920—(Continued)

Title	Location	Requirements	Salary
Assistant Oil Chemist	Bureau of Standards	Two years of college general chemistry	$1400—1800
Junior Chemist	For service in Washington or elsewhere	A.B. degree with 30 hours of chemistry, including at least 6 hours of general inorganic chemistry, 3 hours in qualitative analysis, 8 hours in quantitative analysis, 8 hours in organic chemistry, 6 hours in general college physics	$1200—1800
Assistant Chemist	For service in Washington or elsewhere	College graduation with 30 hours of chemistry plus at least two years of experience in research. One year of graduate work accepted in lieu of each year of experience. Thesis required	$1800—2500
Associate Chemist	For service in Washington or elsewhere	(1) Ph.D. degree with major work in advanced inorganic, analytical, biological, dairy, explosives, food, fuel, metallurgical, organic, pharmaceutical, physical, soil, petroleum, gas or ceramic chemistry, or (2) graduation from college with at least 30 semester credit hours in chemistry plus subsequent work of a research or technical character sufficient in quality and quantity to be regarded as equivalent to a Ph.D. degree. Thesis required.	$2500—3600
Microscopist	Army Medical Museum, Washington	High school graduation plus a year's practical experience in histological technique.	$1800

Positions in Chemistry for Which Federal Civil Service Examinations Were Held

1920—(Continued)

Title	Location	Requirements	Salary
Food and Drug Inspector	Bureau of Chemistry, for duty at Washington and elsewhere	A college course with special work in chemistry, or a degree from a professional school in medicine and pharmacy, or commercial experience or experience in inspection service	$1600
Chemical Engineer	Bureau of Standards, Washington	A bachelor's degree in mechanical engineering, chemical engineering, or in a course majoring in physics and chemistry; at least five years of professional practice, including experience in research work and contact with refinery processes involved in the production of lubricants of all kinds.	$3000—4000
Textile Expert	General Staff, War Department	Ability to read drawings and specifications, general knowledge of cotton, wool, silk, rope and twine fibres, also a knowledge of textile manufacturing processes. Textile chemist with 10 years of experience in the textile industry.	$3500
Gas Expert	Office of Director of Air Service and similar vacancies	High school and not less than five years of experience in general or special industrial chemistry or laboratory research. Each year of additional study considered equivalent to six months of the required experience.	$3600
Specialist in Science Teaching	Bureau of Education	College graduation with special work in the sciences, three years of graduate work, including graduate study of education or its equivalent in executive or administrative experience, and at least five years of experience in science study.	$3500

Positions in Chemistry for Which Federal Civil Service Examinations Were Held

1920—(Continued)

Title	Location	Requirements	Salary
Pharmacologist	Public Health Service and similar vacancies	A B.S. and an M.D. degree plus three years of postgraduate experience in experimental pharmacology or physiology, such experience to have included study of the physiologic action of drugs	$3000
		1921	
Junior Apprentice Junior Aid Senior Aid Laboratory Assistant	Bureau of Standards	Four years high school with two of the following subjects: chemistry, physics, manual training	$540 $720—840 $900 $1000
Chemical Laboratorian, Analytical and Metallurgical	U. S. Naval Academy at Annapolis, Md.	Applicants rated on general chemistry and physics, analytical or metallurgical chemistry, general education and experience	$4.80—5.04 a day
Assayer	Treasury Department	Two years of high school plus one year in general and analytical chemistry plus two years of practical experience in analytical work, six months of which were in metallurgical analysis	$2200
Laboratory Aid in Agricultural Technology	Bureau of Plant Industry	Two years of training of an agricultural character in a recognized college or two years of experience in a chemical or physical laboratory	$840—1200

Positions in Chemistry for Which Federal Civil Service Examinations Were Held

1921—(Continued)

Title	Location	Requirements	Salary
Technological Assistant	Bureau of Fisheries	Graduation with a master's dgree from a recognized college, majoring in chemistry, chemical technology, engineering chemistry, physics or combinations of the above, plus one year of experience in fisheries technology	$2000—2520
Junior Technologist	Bureau of Standards	Graduation from a recognized college with course including the fundamentals of chemistry, mathematics and engineering or physics; or the substitution of experience for two years of college work	$1200—1500
Assistant Technologist			$1500—2000
Associate Technologist			$2000—2800
Technologist			$2800—4000
Associate Technologist qualified in oil research	Bureau of Standards	Four years of high school plus five years of experience in oil testing, including chemical and physical examination of petroleum and its products. Each year of work in college substituted for nine months of experience.	$2000—2500
Junior Chemist	Chemical Warfare Service, Edgewood, Md.	Rating on general chemistry, elementary physics and an optional subject; also general education, training and experience	$1400—2000
Assistant Chemist	Chemical Warfare Service, Edgewood, Md.	Rating on education, training, experience and thesis or publications	$1800—2500
Associate Chemist			$2000—3000
Chemist			$3000—5000

Positions in Chemistry for Which Federal Civil Service Examinations Were Held

1921—(Continued)

Title	Location	Requirements	Salary
Food and Drug Inspector	Bureau of Chemistry	Experience in inspection service, especially of food and drugs; or a college course with special work in chemistry; or a degree in medicine; or an equivalent in training and experience	$1600
Specialist in the chemistry of food preparation	States Relations Service	Graduation from a recognized college with a degree in home economics and completion of one year of postgraduate work in chemistry, physics or some biological science, plus one year of experience in college teaching of home economics or closely allied subjects, or in full-time paid work on some allied responsible position giving contact with the immediately pressing problems of home economics. Articles prepared and published were to be submitted	$2300—2500
Junior Pharmacologist	Public Health Service	Graduation from college with a course including biology, physiology or pharmacology with six months of practical laboratory experience in biology, physiology or pharmacology.	$1500—2000
Assistant Pharmacologist	Bureau of Chemistry	Rating on basis of education, training and experience	$2000—2500

Positions in Chemistry for Which Federal Civil Service Examinations Were Held

1921—(Continued)

Title	Location	Requirements	Salary
Pharmacologist	Bureau of Internal Revenue	Graduation from a recognized college with undergraduate courses in physiology and pharmacology. Special credit given for undergraduate or graduate work in pharmaceutical chemistry. Some experience required	$2500—3000
Junior Metallurgist	Bureau of Mines	Graduation from a recognized college with major work in metallurgy plus experience	$1500—1800
Assistant Metallurgist			$2600—2800—3000
Associate Metallurgist			$3000—3800
Metallurgist			$3000—3600—4000—4800
Assistant Chemist in Forest Products	Forest Service	Rating based on education, experience and fitness	$1500—2100
Associate chemist in Forest Products			$2160—2340
Chemist in Forest Products			$2400—3600

In the three fiscal years ending respectively June 30, 1919, 1920 and 1921, there were 1957 applicants who entered federal civil service examinations for positions in chemistry; of these, 1,763 were men, 194 or 9.9 per cent were women. Of the 1,763 men, 1,233 or 69.9 per cent, and of the 194 women, 149 or 76.8 per cent passed these examinations. The appointments during these three years were probably not all made from among those who passed the examinations during that time, as there were doubtless eligible candidates from previous examinations; the figures nevertheless have some significance. There were appointed to departmental or field service 473 men, a figure representing 38.3 per cent of the number who passed examinations in this period, and 38 women, representing 25.5 per cent of the number who passed examinations in the same period.

Women were appointed to positions as chemical laboratorian, chemist's aid, microscopist, microanalyst, assistant explosives chemist, assistant metallurgical chemist, sugar chemist and technologist; they successfully passed examinations, in addition, for the positions of analyst, assistant in pharmacology, assistant chemist, associate chemist, biochemist, chemist in forest products, metallurgical laboratorian, and specialist in science teaching. The details of the report of the Federal Civil Service Commission in regard to positions in chemistry are given in the following table. Positions such as laboratory helper, laboratory assistant, etc., which are not defined in the report as chemical, have not been included.

The separate Government departments in which chemists and allied workers are employed, the number of such employees and the general character of their work are briefly described in the following sections.

DEPARTMENT OF AGRICULTURE

The several divisions of the Department of Agriculture in which chemists and allied workers are employed are the Bureau of Animal Industry, the Bureau of Plant Industry, the Forest Service, the Bureau of Chemistry, the Bureau of Soils, the Bureau of Public Roads, the Office of Home Economics of the States Relations Service and the various Agricultural Experiment Stations affiliated with this Service. The Department of Agriculture reports the following number and designation of employees at present engaged in chemical and allied work in the various divisions of

Number Examined, Number Passed and Number Appointed

During the Fiscal Years Ending

Position	Number Examined					
	1919		1920		1921	
	M.	W.	M.	W.	M.	W.
Aeronautical chemist	5	....	4	....	2	....
Analyst	....	....	....	....	7	3
Assistant analytical chemist and mineralogist	1	....	....	....	....	....
" assayer	4	....	1	....	....	....
" biochemist	1	....	....	....	....	....
" catalytical chemist	2	....	9	....	....	....
" chemical engineer	8	....	2	....	....	....
" chemist	11	....	....	....	46	3
" chief chemist	....	....	6	....	....	....
" in charge of soil chemistry investigations	....	....	2	....	....	....
" chemist in forest products	14	....	....	....	17	2
" chemist and metallurgist	4	....	....	....	....	....
" metallurgical chemist	55	....	9	7	10	3
" in pharmacology	8	1	1	....	....	....
" powder and explosives chemist	27	1	3	....	3	....
" superintendent nitrate and chemical plant	37	....	1	....	....	....
Associate chemist	71	2	43	7	128	4
" organic chemist	....	....	....	....	....	....
Biochemist	8	2	....	....	....	....
Catalytical chemist	2	....	2	....	1	....
Chemical engineer	79	....	10	....	18	....
" laboratorian	81	25	74	18	22	....
Chemist	....	....	....	....	24	....
Chemist's aid	38	4	25	2	....	....
Chief metallurgist	....	....	5	....	....	....
Consulting chemist	....	....	....	....	1	....
Food chemist	....	....	....	....	1	....
Food research chemist	....	....	....	....	....	....
Fuel research assistant	....	....	....	....	2	....
Gas expert	....	....	....	....	5	....
Junior catalytical chemist	1	....	8	....	3	....
" chemist	248	56	107	21	204	17
" gas chemist	....	....	2	....	....	....
" metallurgist	....	....	....	....	....	....
" pharmacologist	....	....	....	....	11	4
Kelp plant chemist	....	....	1	....	....	....
Laboratory aid and junior chemist	....	....	....	....	....	....
Metallurgical chemist	64	....	8	....	7	....
" laboratorian	9	1	....	....	7	....
Metallurgist	6	....	12	....	23	....
Microanalyst	....	....	1	4	1	1
Microscopist	....	....	....	....	1	4
Oil chemist	....	....	8	....	2	....
Organic and physical chemist	1	....	....	....	1	....
Pharmacologist	....	....	2	....	2	....
Photochemist	....	....	....	....	....	....
Powder and explosives chemist	17	....	....	....	....	....
Research chemist	....	....	15	....	4	....
Sanitary chemist	1	....	....	....	....	....
Soil biochemist	15	....	....	....	....	....
Sugar chemist and technologist	7	....	....	....	....	....
Superintendent of nitrate and chemical plants	....	....	....	....	....	....
Specialist in science teaching	....	....	9	2	2	....
Textile expert	....	....	13	....	....	....
Total	825	92	383	61	555	41

for Positions in Chemistry in the Federal Civil Service

June 30, 1919, 1920 and 1921

Number Passed						Number Appointed In Departmental Service						Number Appointed In Field Service					
1919		1920		1921		1919		1920		1921		1919		1920		1921	
M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
5		3		2													
				4	2												
1												1					
4		1												2			
1																	
2		2						1						4			
6		2						1						1		1	
4				28	3	6		4		2		28		4		2	
		4						2									
		2															
12				11	2							4				1	
4																	
32		7	2	6	2							22		4	2	4	
1	1					1											
22	1	3		3								16		2			1
27		1															
35	2	31	5	91	3	9		6		7		2		6		2	
												1					
7	2																
2		1		1										1			
67		10		15								2		7		2	
59	20	59	15	11		14	1	12	1	3		8	5	13		8	1
				13		1										2	
29	4	22	2			3	1	2		1							
		5															
				1													
				1												1	
												1					
				2													
				2												1	
1		2		2												1	
148	44	109	14	162	13	44	8	29	6	31	2	29	1	42	2	15	2
		1															
								1									
				3	2												
		1															
												1					
52		5		6								22		9		1	
2	1			2								1	1			1	
2		6		10				3						3		1	
		1	3	1	1				1						1		
				1	3						1						
		3		1				1									
1				1													
		2		1													
						1											
9												2		2			
		6		1													
1																	
12						1		1									
5															1		
												1					
		7	2	1													
		1												1			
553	75	297	43	383	31	80	10	63	8	44	3	142	7	101	6	43	4

the Department. It is evident that in some of these positions chemistry is subsidiary to the main work, as, for example, in the case of the mycologist, the bacteriologist, and the junior mechanical engineer.

Designation and Number of Employees Engaged in Chemical Work in the Department of Agriculture, February 11, 1922

Designation	Men	Women	Total
Assistant Chemist	74		74
Junior Chemist	91	9	100
Associate Chemist	19		19
Chemist	27		27
Dairy Chemist	2		2
Organic Chemist	8		8
Physical Chemist	1		1
Physiological Chemist	1		1
Organic and Physical Chemist	2		2
Chemist in Forest Products	11		11
Associate Chemist in Forest Products	1		1
Assistant Chemist in Forest Products	7		7
Catalytical Chemist	1		1
Assistant Catalytical Chemist	1		1
Research Chemist	1		1
Junior Catalytical Chemist	3		3
Assistant Explosives Chemist	1		1
Consulting Chemist	9		9
Chief, Biochemic Division	1		1
Biochemist	6		6
Senior Biochemist	3		3
Associate Biochemist	1		1
Assistant Biochemist	4		4
Soil Biochemist	2		2
Biological Chemist	1		1
Chief, Drug Division	1		1
Chemical Biologist	3		3
Chemical Laboratorian	20	1	21
Chemical Engineer, Grade 1	4		4
Chemical Engineer	1		1
Chemical Engineer, Grade 2	2		2
Assistant Chemical Engineer	1		1
Junior Mechanical Engineer	1		1
Ionic Physicist	1		1
Chief, Miscellaneous Division	1		1
Mycologist in Charge	1		1
Microscopist in Charge	1		1

Designation and Number of Employees Engaged in Chemical Work in the Department of Agriculture, February 11, 1922—(Continued)

Designation	Men	Women	Total
Chief, Synthetic Drug Products Laboratory	1		1
Pharmaceutical Research Chemist	1		1
Pharmacognocist in Charge	1		1
Chief, Essential Oils Laboratory	1		1
Chemist in Charge, Cattle and Stock Feed Laboratory	1		1
Assistant Pharmacognocist	1		1
Pharmacologist in Charge	1		1
Junior Pharmacologist	1		1
Technical Administrative Assistant	1		1
Crystallographer	1		1
Medical Assistant		1	1
Microanalyst	3	3	6
Bacteriologist	3		3
Dairy Bacteriologist	1		1
Chief, Miscellaneous Division and Chairman	1		1
Chief, I. & F. Laboratory	1		1
Research Operator in Metallurgy	1		1
Cement Tester	1		1
Scientific Assistant	4		4
Assistant in Fermentation Mycology		1	1
Assistant in Plant Histology	1		1
Assistant in Fish Investigations	1		1
Assistant in Charge of Soil Chemical Investigations	1		1
Scientist in Soil Laboratory Investigations	17		17
Scientist in Investigation of Fertilizer Resources	1		1
Chemist's Aid	2		2
Laboratory Inspector	18		18
Laboratory Aid	1	1	2
Laboratory Helper	46	12	58
Laboratory Mechanician	2		2
Laboratory Assistant	4		4
Laboratory Aid and Engineer	34	1	35
TOTALS	468	29	497

Bureau of Animal Industry. Chemists are employed in the Bureau of Animal Industry in the federal meat inspection, which in 1920 covered 897 establishments in 262 cities and towns; in the investigation of the manufacture and handling of all dairy products—butter, cheese, ice-cream, and the utilization of dairy by-products; in the study of animal feeds and problems of animal nutrition. Meats and meat products prepared for the army and navy are also analyzed here.

In the pathological division investigations are conducted cover-

ing diseases in animals, poisoning of livestock by plants, viruses and serums used for the treatment and prevention of ailments in domestic animals and similar matters. Many pathological specimens are received for diagnosis.

The division of biochemistry is occupied with investigations relative to meat and meat food products; studies of dips and disinfectants and improvement of their manufacture; the preparation of tuberculin and mallein, studies of special diseases like hog cholera, and similar problems.

Bureau of Plant Industry. This Bureau is concerned with the culture and methods of utilization of plants. Biochemists are in charge of soil fertility investigations—the comparison of American potash materials, the effect of borax in fertilizers, the potash requirements of the potato and cotton plants, new fertilizer materials, the best ratio of nitrogen, phosphate and potash, etc. Experimental work is carried on in field stations in all sections of the United States. Chemists are also engaged in studying the problems involved in the handling and storage of fruits and vegetables and in the development of methods of harvesting, transporting and storing whereby decay, deterioration and loss may be reduced to a minimum. Special studies are made of problems relating to the utilization of plant products—for example, the clarification of fruit juices, the technology of vegetable oil production and refining, and the like.

The Forest Service. The Forest Service maintains a forest products laboratory at Madison, Wisconsin, for research in the properties of various woods, glues and wood preservatives, and wood distillation products. New uses for waste products are also developed such as the production of a stock feed from wood, wood pulp for nitrocellulose.

The Bureau of Chemistry. More chemists are employed in this Bureau than in any other Government division. The Bureau of Chemistry is responsible for the enforcement of the Pure Food and Drug Act which went into effect in June, 1906; it has adopted the United States Pharmacopœia and the National Formulary as the legal standards of the quality and purity of drugs. Chemists, microanalysts and bacteriologists are constantly engaged in examining foods, feeds and drugs which are referred to the Bureau. Imported foods and drugs are all tested. Foods used by the army and marines are analyzed. In the laboratory at Washington are stored samples of fraudulent products, such as mold from a $50,000 lot of canned tomatoes confiscated by the Government, "condition

powder" which had killed a herd of 96 hogs, cloves which were put on the market after their oil had been extracted. There is also a large collection of verified products which are used as norms.

In the year 1920, 1407 recommendations for seizure and 851 recommendations for criminal prosecution were made to the Department of Justice through the office of the Solicitor in the Department of Agriculture, mostly on patent medicines, mineral waters, stock feeds, edible oils, flavoring materials, eggs and egg substitutes, fruit and vegetable products of gelatin, fish and shell fish, and saccharin. Everyone engaged in the law enforcement work of the Bureau must be ready to swear by the analyses made if a case is brought to court, which is an additional stimulus to accuracy and honesty.

Laboratories to which food and drugs are submitted for analysis are located in Baltimore, Boston, Buffalo, Chicago, Cincinnati, Denver, Minneapolis, New Orleans, New York, Philadelphia, St. Louis, San Francisco, San Juan, Savannah and Seattle. In a number of these laboratories women have been working as chemists, as microanalysts and as bacteriologists. Experience in these laboratories is excellent preparation for a responsible position in state or federal public health and food work.

Law enforcement is only one phase of the work of the Bureau of Chemistry. Constructive research is conducted which is designed to promote efficiency in food and drug industries and to develop new methods for the discovery and detection of "sophistication." In the carbohydrate laboratory studies have been made, among other subjects, of various sugars, glucose, maltose, etc.; of new sources and uses of syrups; of the production of rare sugars; of the use of corn cobs.

Fats and oils have also been studied; for example, the nature and proportion of the fatty acids in cottonseed oil have been determined; the physical and chemical constants of a large number of oils from all parts of the country were measured and found surprisingly uniform.

New laboratories have recently been established at San Diego and at Pensacola. To the former was assigned the study of the methods of canning and preserving Pacific Coast fish and the utilization of by-products; in the latter the composition and food value of gulf fishes and methods of preparing and handling them are studied. Considerable research in the handling, cold storage and transportation of fresh fish has been conducted by the Bureau of Chemistry, also in related subjects such as the effect of affluents from paper and pulp mills on the quality of oysters.

Analytical and microscopic methods have been worked out for distinguishing fresh from remade milk, also a volumetric method for the detection and estimation of neutralizers in butter. The quality of milk used in the preparation of evaporated, condensed and dried milk has been investigated. In a special division investigations in the dehydration of fruits and vegetables have been conducted.

The Drug Division makes investigations of drugs and medicines, studies methods of analysis, cooperates with the Association of Official Agricultural Chemists, the Pharmacopœial Committee of revision and assists the Post Office Department in purging the mails of medical and other schemes to defraud.

In the pharmacognosy laboratory crude drugs, the composition and the effect of drugs are studied. A special color laboratory was established during the war at Arlington. Problems of leather and tanning have also been studied as have the causes and prevention of plant dust explosions and fires in mills and elevators. Various other lines of investigation are followed in the course of the research which the Bureau of Chemistry undertakes.

Fixed Nitrogen Research Laboratory. The principal function of the Fixed Nitrogen Research Laboratory consists in conducting research on methods of fixing the nitrogen of the atmosphere for agricultural, industrial and military purposes. This includes the improvemeint of the existing processes (Cyanamid, Haber, Arc and Cyanide), the discovery and development of new processes, and the study of the transformation of nitrogen compounds from one form to another; 48 chemists of various grades are employed.

The Bureau of Soils. In the laboratory of soil chemistry many soil analyses are constantly made for the various bureaus of the Department of Agriculture, for other departments, and for hundreds of farmers, gardeners and city and suburban dwellers. Important investigations have also been conducted in the production of fertilizers—the fixation of nitrogen from the air, the recovery of potash from cement plants, from blast furnaces and from kelp, the manufacture of concentrated fertilizers. The significance of complex mineral salts in various soil types is as yet very little understood and offers a subject for considerable future study on the basis of initial investigations which this Bureau has made.

Bureau of Public Roads. Road materials of all sorts are tested in this Bureau. In 1920, 783 samples were tested in the

chemical laboratories of which 365 were classified as bituminous, 406 as metal and 12 as miscellaneous. In addition 40 samples of smelter slags and 29 of blast furnace slags were analyzed. Research on road materials is also carried on; such matters have been studied as the chemical composition of blast furnace and smelter slags, metal for culvert pipes, dust preventives and road binders. There has also been research on the standardization of methods of testing.

The States Relations Service. The chief aims of the States Relations Service are to promote agricultural research through the agricultural experiment stations and to improve farming and home life through extension work in agriculture and home economics and through investigations in home economics.

1. In the Office of Home Economics of the States Relations Service are conducted experimental studies in food preparation, studies in the digestion of foods, research in the handling and storage of food products and related matters. Many bulletins are issued in which the results of these investigations are made available freely throughout the country.

Women trained in chemistry are employed here as food and nutrition specialists; a combination of home economics and chemical training is preferable to training in chemistry only.

2. The agricultural experiment stations and state agricultural colleges in the various states receive federal support and supervision, advice and assistance from the Department of Agriculture through the States Relations Service. The Experiment Station Record, in which are included summaries of investigations conducted at individual stations, is published in Washington. There is no research staff in the Washington office except that library research is constantly conducted.

A woman chemist, employed in the central office as specialist in agricultural and food chemistry describes her work as consisting primarily in looking over current scientific literature from all countries and abstracting for publication all important material on agricultural chemistry, nutrition, immunity work in veterinary medicines, etc. She answers many questions from outside correspondents and furnishes bibliographical material to workers in the Department of Agriculture.

Research and analytical positions for chemists exist in many of the state agricultural experiment stations; when they are associated with state universities these positions may involve also some teaching and related duties. The research conducted in these sta-

tions requires also scientists who are well grounded in physiological botany as well as in chemistry; it has been pointed out that there is a dearth of such workers—chemists who have good botanical training or botanists who are trained in chemistry.

The work in chemistry is not separately recognized in all stations but is in various instances carried out in the department particularly concerned—agronomy, animal nutrition, plant pathology, home economics, etc.

Women chemists have been doing valuable work in agricultural experiment stations. For years Edna Terry served in the department of protein research of the Connecticut Agricultural Experiment Station at New Haven. The director wrote after her death that she had been an invaluable member of the staff, and her work admirable. Emma Francis recently resigned her position as head of the nutrition laboratory at the Battle Creek Sanitarium to accept an appointment as assistant professor of chemical agriculture in the Experiment Station at Pennsylvania State College. Dr. Nellie E. Goldthwaite carried on potato investigations in the station at Fort Collins, Colorado, for the purpose of determining the quality of varieties, also the effect of soil and climate on quality.

Practical farm experience and a knowledge of farm matters have been considered desirable for work on agricultural problems and as a basis for meeting farmers and discussing their problems with them intelligently. Women chemists have seldom possessed this knowledge and experience. Adequate training is, however, increasingly emphasized as the chief requisite for the scientific work of these stations.

"The problems now under investigation in most experiment stations are as a rule very technical ones, but often involve much routine analytical work. We have come to a point where practically every head of the Department of Agricultural Chemistry in Experiment Stations must have done graduate work; in other words, must possess a Ph.D. degree. I presume that very few women will find the field attractive enough in the immediate future to induce them to make the preparation in chemistry that is necessary for the head of a department devoted to research in chemistry." *(Director of a college of agriculture and an agricultural experiment station.)*

A woman who is assistant chemist in a state station and also teaches some chemistry in the state university has emphasized the need of a knowledge of botany, zoology and physics with the ability to read German readily as essential concomitants to thorough train-

ing in chemistry. "A broad foundation must be laid for any specialized field."

In various stations no women have ever been employed. During the war emergency women were taken on for the first time in many states and the results reported have with very few exceptions been entirely satisfactory. A number of directors from all parts of the country have reported that women chemists have done good work on their staffs in home economics, in the study of vitamines in human food, in analyses of flour and baking tests, in animal nutrition, in soil analysis and research, etc. In too frequent instances women were not employed to any extent outside of the clerical force owing to the fact that those with proper training for the scientific branches could not be found.

In short, women have just begun to enter the field of chemistry as applied to agriculture, and there should be considerable development of the beginnings made. The experience reported by one station may be quoted as indicative of the progress that has been made, and of how much more can be done by women in this field.

"We have employed women in our chemical laboratory with satisfaction to those who have had them in charge. We were obliged to employ women as a result of war conditions. We have had four in all during the past three years. One has gone to a better position in home economics, and one has gone away for graduate study in biology. We have two at the present time, one of whom is rated at $1320 salary and the other at $1560. We have employed them in all cases on the routine chemical analysis which is required in connection with our investigations and with our fertilizer and feeding stuffs inspection. We have not had an opportunity to judge their capacity for original research and do not know whether women will be interested in problems pertaining to agriculture. I can see no reason why women should not have the same interest in problems of soil fertility and of animal nutrition, the chemistry of the dairy industry, and similar problems, that a man might have. I also know of no reason why they should not be successful.

"There was of course a prejudice against employing women until we were actually obliged to do so. I think, however, that prejudice has disappeared from the minds of nearly everybody connected with our laboratories.

"As far as my own observation has gone in coeducational institutions there have been very few young women who have shown a

marked interest in chemical studies and I have been led to believe that as a science it does not appeal to them."

(*Acting director of an agricultural experiment station.*)

A woman assistant in animal nutrition at an agricultural experiment station believes that "there is work for women chemists in the agricultural field, if they are willing to adapt themselves to the work to be done and prove their fitness for it. . . . Such investigations and teaching as are a part of home economics and human nutrition, of course, are almost entirely in the hands of women. Animal nutrition is closely enough like human nutrition on the chemical side easily to employ the same women. Then there is a great deal of routine analysis, mainly of food and soils, for which some women have trained and more can if the work appeals to them. There are also places requiring a combination of chemistry and bacteriology. There is some call for abstracting, including foreign languages (especially German), editorial, writing and library work, and women are peculiarly fitted for such work."

The evidence all justifies the conclusion expressed by the chemist of one state station: "I believe there are positions in every experiment station laboratory where women can be used as well as men and where they will render just as efficient service. I believe there will be a tendency in the future to employ more of them."

At the time of the most recent report[1] 64 agricultural experiment stations were affiliated with the Department of Agriculture.

Agricultural Experiment Stations Affiliated with the Department of Agriculture

Alabama
- College Station, Auburn
- Canebrake Station, Uniontown
- Tuskegee Station, Tuskegee Institute

Alaska
- Sitka

Arizona
- Tucson

Arkansas
- Fayetteville

California
- Berkeley

Colorado
- Fort Collins

Connecticut
- State Station, New Haven
- Storrs Station, Storrs

Delaware
- Newark

Florida
- Gainesville

Georgia
- Experiment

Guam
- Guam

Hawaii
- Federal Station, Honolulu
- Sugar Planters Station, Honolulu

Idaho
- Moscow

Illinois
- Urbana

Indiana
- Lafayette

[1] Yearbook of the U. S. Department of Agriculture, 1920.

Iowa
  Ames
Kansas
  Manhattan
Kentucky
  Lexington
Louisiana
  State Station, University Station
  Sugar Station, New Orleans
  North Louisiana Station, Calhoun
  Rice Station, Crowley
Maine
  Orono
Maryland
  College Park
Massachusetts
  Amherst
Michigan
  East Lansing
Minnesota
  University Farm, St. Paul
Mississippi
  Agricultural College
Missouri
  College Station, Columbia
  Fruit Station, Mountain Grove
Montana
  Bozeman
Nebraska
  Lincoln
Nevada
  Reno
New Hampshire
  Durham
New Jersey
  New Brunswick
New Mexico
  State College
New York
  State Station, Geneva
  Cornell Station, Ithaca
North Carolina
  Raleigh
North Dakota
  Agricultural College
Ohio
  Wooster
Oklahoma
  Stillwater
Oregon
  Corvallis
Pennsylvania
  College Station, State College
  Institute of Animal Nutrition, State College
Porto Rico
  Federal Station, Mayaguez
Rhode Island
  Kingston
South Carolina
  Clemson College
South Dakota
  Brookings
Tennessee
  Knoxville
Texas
  College Station
Utah
  Logan
Vermont
  Burlington
Virginia
  College Station, Blacksburg
  Truck Station, Norfolk
Virgin Islands
  St. Croix
Washington
  Pullman
West Virginia
  Morgantown
Wisconsin
  Madison
Wyoming
  Laramie

DEPARTMENT OF COMMERCE

Bureau of Standards. The following classification indicates the positions of chemists in the Bureau of Standards with the number of persons occupying such positions. Outside of the Bureau of Standards there is but one chemist holding appointment in the Department of Commerce, and that is an assistant chemist in the Lighthouse Service, Tompkinsville, New York.

Designation and Number of Chemists and Technologists, Bureau of Standards, February 11, 1922

Designation	Men	Women	Total
Junior Aid	1		1
Senior Aid	3		3
Laboratory Assistant, Junior Grade	2		2
Laboratory Assistant, Senior Grade	8		8
Assistant Chemist	15	4	19
Associate Chemist	20		20
Chemist	11		11
Chief Chemist	1		1
Associate Chemical Engineer	1		1
Ceramic Chemist	1		1
Technologist	3		3
Associate Technologist	8		8
Assistant Technologist	1		1
Consulting Chemist	2		2
Consulting Metallurgist	1		1
TOTALS	78	4	82

The maintenance on the part of the Government of correct standards of measurement or quality of performance calls for continuous scientific and technical investigations of the highest grade, involving the most competent service and the best scientific equipment. The testing laboratory of the Bureau also assists in placing Government purchases upon an economical and businesslike basis. Supplies are tested for various Government divisions.

Practically all investigations concerning the various classes of standards involve chemistry in one form or another. There are also many chemical standards to be determined and questions which arise in connection with chemical work generally to be answered. The Chemical Division cooperates with every other division of the Bureau; primarily it takes care of the questions of a purely chemical nature that come to the Bureau and which fall within its functions—the chemical composition and purity of material, chemical properties and constants including research upon methods of analysis, specifications for technical materials and preparation of pure materials for the standardization work of the Government and for industrial and scientific laboratories. The Chemical Division is divided into nine sections.

1. The section on physical chemistry is concerned with the preparation and purification of materials required in physical measurements of precision—refrigeration materials, colorimetric samples, glass-to-metal joints, critical solution temperatures, and the like.

2. The section on electrochemistry is concerned with studies of the electrodeposition used in electrotyping and electroplating; investigations of zinc, lead, nickel, copper, silver plating, etc.

3. The section on metallurgical chemistry is engaged in the preparation of metals and alloys required in connection with metallurgical investigations, and in the study of special methods of analysis for such products.

4. The section on gas chemistry studies the methods of preparation, purification and testing of gases, including fuel and illuminating gas and special gases such as hydrogen, nitrogen, oxygen, argon. The preparation of a bibliography of scientific literature relating to the physical and chemical properties of gases and many related subjects has been undertaken in this section; over 11,000 items had been listed when the bibliography was probably less than half complete.

5. The section on reagents and apparatus is engaged in the study of methods of testing reagents and apparatus to be used in chemical analyses, including a study of chemical glassware, porcelain, platinum and platinum substitutes.

6. The section on analytical methods and standard samples conducts investigations covering general methods of chemical analysis with special reference to methods of standardization—the preparation and analysis of standard samples of iron, steel alloys, ores, chemicals, etc.

7. A separate section is devoted to the chemical analysis and investigations of lubricating oils, rubber, paper, textiles, ink, glue, and other materials, with special reference to meeting particular requirements. Such materials as pearl buttons, fireproofing fabrics, filter paper, typewriter ribbons, carbon papers, etc., have been referred to this section.

8. An important section is concerned with metals, cement, bituminous materials, etc.—the chemical analysis of iron, steel, nonferrous metals, alloys such as brass, type metal and solder, coated metals such as tin plate and galvanized metals; lime, plaster, cement, concrete; and bituminous materials such as tar, asphalt, roofing, roofing felt.

9. There is a section, finally, for the chemical analysis, testing and exposure tests of paint and varnish and the chemical analysis of and specifications for soap.

The Metallurgical Division of the Bureau of Standards has a section on chemical metallurgy in which are studied iron alloys, total gases in steel, the preparation of pure aluminum, and the like.

The Ceramics Division is concerned with the principles involved in the production of the many kinds of clay products such as the various structure materials, pottery, electrical porcelain, refractories, the manufacture of different types of glass, and the enameling of metals. Owing to the fact that these industries are of basic importance in the development of the country and have not yet received systematic technical study, the Bureau of Standards considers that research which would help them to expand more rapidly is of considerable importance. In this study various trade associations of these industries are cooperating.

Although the number of women chemists in the Bureau of Standards has been small and their employment recent, they are demonstrating their ability in various forms of work as the following brief summaries of duties of several of them indicate:

"Chemical analysis of cement and related materials."
(*Analytical chemist.*)

"Analysis of electroplating solutions, working out new solutions, regular research problems on various sets of conditions, etc."
(*Research analyst.*)

"I do some routine testing of the permeability of balloon fabrics to hydrogen. My main task is compiling a bibliography of all the literature that has been published on gases." (*Assistant chemist.*)

"Testing of imported sugars for the United States Customs Service." (*Chemist's assistant.*)

"I have charge of all standard samples issued by the Bureau. I weigh, bottle, and send them out. I actually do no work in chemistry but a general knowledge of chemistry is necessary to enable me to understand the work." (*Laboratory assistant.*)

All emphasize the need of a thorough knowledge of the basic principles of chemistry. There is agreement also as to the stimulus attending work in so scientific an organization. "Government work brings one into contact with the best of scientists. There is some opportunity to travel and all the Government bulletins are available. The scientists here are recognized the world over for their work and one meets many of the geniuses of the field."

DEPARTMENT OF THE INTERIOR

In the Department of the Interior chemists are employed in the Bureau of Mines, in the Geological Survey and in the Patent Office. The number of present employees is reported as follows:

Designation and Number of Employees Engaged in Chemical Work in the Department of the Interior, February 20, 1922

Designation	Men	Women	Total
Alloy Chemist	2		2
Analyst	2		2
Assistant Chemist (including assistant chemists in special lines)	20		20
Associate Chemist	2	1	3
Assistant Metallurgist	3		3
Assistant Technologist	1		1
Chemical Engineer	2		2
Chemist (including chemists in special lines)	28		28
Chief Chemist	3		3
Consulting Chemist	18		18
Consulting Metallurgist	12		12
Junior Chemist (including junior chemists in special lines)	23		23
Laboratorian	2		2
Laboratory Assistant, Helper	13		13
Metallurgist	9		9
TOTALS	140	1	141

The Bureau of Mines. The director of the Investigations Branch of the Bureau of Mines acts in an advisory capacity for all the chemical work of the Bureau. There are four chief divisions of this branch:

1. The Fuels Division conducts chemical research on fuels at the Bureau laboratory in Pittsburgh; fuels purchased by the Government are all analyzed here. The laboratory has also served the governments of Switzerland and the Netherlands by analyzing the coal exported to these countries.

2. In the Division of Mineral Technology have been investigated alloy steels, the uses and methods of preparing radium, electric brass furnaces, the production of phosphor copper by electric smelting, the chemistry and metallurgy of platinum, vanadium, molybdenum, and similar subjects in large variety.

3. In the Metallurgical Division such studies as the treatment of low-grade copper ores, methods of producing sponge iron, mining and milling methods for lead and zinc ores, etc., are conducted, principally by metallurgists at various mining experiment stations.

4. The Division of Petroleum and Natural Gas is concerned with the investigation of all matters that pertain to these products. The analytical distillation of petroleum, the heating value of treated and untreated natural gas, the determination of the substances in gasoline causing gumming and corrosion, etc.

Eleven mining experiment stations are maintained which in several instances collaborate with the state universities in research work. To each of them are assigned for investigation the problems pertinent in the general geographic district which the station represents. The location of these stations, with some of the leading subjects of investigation, is as follows:

Bartlesville, Oklahoma. The chemical technology of petroleum.

Berkeley, California. Methods of utilizing the potash in the Searles Lake deposits.

Columbus, Ohio. White clay investigations, the use of graphite for crucibles, and the like.

Fairbanks, Alaska. Weather tests on lignite and spruce; metallurgical work.

Golden, Colorado. The rare metals; methods for the analysis of radium, uranium, vanadium and molybdenum.

Minneapolis, Minnesota. Iron ores.

Pittsburgh, Pennsylvania. Routine examinations of fuels belonging to the Government and of all materials required for investigations made by experiment stations and geological surveys. Microscopic investigations of coal, graphite, the constitution of coal explosives, coal and rock dust, and miscellaneous materials. Chemical research on coal, coke, by-products, mine gas, fuel gas, industrial gas masks, coal mine explosions.

Salt Lake City, Utah. Methods of treating profitably the low-grade and complex ores of the state, the separation of lead and zinc, the utilization of low-grade alunite deposits for the manufacture of potash. Microscopic analysis of ores and minerals for various other bureaus, and for many mines.

Seattle, Washington. The mining and utilization of western coals, the ceramic value of the clays of the district.

Tucson, Arizona. Copper.

Urbana, Illinois. The occurrence and distribution of sulphur in coal, coal washing, water gas manufacture.

In addition to these experimental stations, there are field offices at Dallas, Texas; Ithaca, New York; Moscow, Idaho, and San Francisco, California, at which special investigations are conducted.

Geological Survey. In the Geological Survey qualitative and quantitative analyses and mineralogic determinations of rocks and minerals are made. Many important investigations are carried on also in the division of chemical and physical research in which there are employed approximately 7 chemists, 2 physicists, 4 laboratory helpers. A few of the recent results attained in this laboratory may be cited to indicate the character of the work undertaken.

The quality of the surface waters of the United States has been studied; color-standard tubes for the determination of hydrogen-ion concentrations in sea water were prepared after an exhaustive study; a new mineral, brannerite, which contains helium, has been analyzed and described; the effect of nitric acid on certain rocks has been studied; a microscopic study has been made of minerals in their various degrees of hydration; new analytical methods are constantly tested.

Patent Office. While the Patent Office does not require any entrant into the examining corps to be a specialist in any profession, many of the examiners have specialized in chemistry in college and professionally and have taken an examination in chemistry for entrance into the examining corps.

DEPARTMENT OF THE NAVY

Chemists and allied workers are employed in the Navy Department at various navy yards and supply depots and ordnance plants and departments to inspect materials used in construction and ordnance and various supplies required by the navy. These employees are all men. The following statement indicates their number, title and distribution:

Designation and Number of Employees Engaged in Chemical Work in the Navy Department and Naval Establishment, February 8, 1922

Navy Yard, Boston, Mass.		
Laboratory Electrician.	1	Production Department
Metallurgist	1	" "
	2	
Navy Yard, Brooklyn, N. Y.		
Assistant Chemist.....	7	Supply Department
Chemist	3	" "
Chief Chemist	1	
	11	
Navy Yard, Washington, D. C.		
Assistant Chemist.....	7	Ordnance Department
Laboratorian	1	" "
Chemist	2	" "
Laboratorian	2	Engineering Department
Laboratorian, Radio...	5	" "
Laboratorian	1	Construction and Repair Department
Chemical Engineer....	1	Naval Air Station, Anacostia, D. C.
	19	

Navy Yard, Philadelphia, Pa.

Physical Metallurgist..	1	Industrial Department
Metallurgical Chemist.	1	" "
Chemist	2	" "
Assistant Chemist.....	5	Supply Department
Chief Chemist.....	1	" "
	10	

Bethlehem Steel Works, Bethlehem, Pa.

Chemical Laboratorian.	1	Office of Inspector of Engineering [Material
Chemist	1	
	2	

Highland Building, Pittsburgh, Pa.

Chemist	1	Office of Inspector of Engineering [Material

Homestead Steel Works, Munhall, Pa.

Assistant Chemist.....	2	Office of Inspector of Ordnance

Navy Yard, Norfolk, Va.

Assistant Chemist.....	2	Supply Department
Chemist	1	" "
Chemist	1	Inside Superintendent's Office
	4	

Navy Yard, Mare Island, Cal.

Laboratorian	2	Industrial Department
Chemist	1	" "
Chemist	1	Supply Department
Laboratorian	2	Radio Office
	6	

Navy Yard, Puget Sound, Wash.

Chemist	1	Supply Department
Radio Laboratorian...	1	" "
	2	

Navy Supply Depot, 29th St. and Third Ave., South Brooklyn, N. Y.

Chemist	2	Provisions and Clothing Administra- [tions

Naval Operating Base, Hampton Roads, Va.

Chief Chemist.....	1	Naval Supply Station
Assistant Chemist.....	1	" " "
	2	

United States Naval Ordnance Plant, South Charleston, W. Va.

Metallurgical Chemist.	5	Inspection Division
Assistant Metallurgist.	4	" "
Chief Metallurgical Chemist	1	" "
Metallurgist	1	" "
	11	

Naval Proving Ground, Indian Head, Md.

Assistant Chemist.....	5	Ordnance Department
Chemist	5	" "
Chief Chemist.....	1	" "
	11	

United States Naval Academy, Annapolis, Md.

Laboratorian, Mechanical	7	Naval Engineering Experiment Station
Laboratorian, Chemical	4	" " " "
Laboratorian, Metallurgical	7	" " " "
Laboratorian, Photographical	1	" " " "
Laboratorian, Electrical	1	" " " "
Assistant Chemist.....	1	" " " "
Chemist	1	" " " "
Metallurgist	1	" " " "
	23	

United States Naval Torpedo Station, Newport, R. I.

Assistant Chemist.....	2	Ordnance Department
Chemist	1	" "
	3	

Grand Total.....111

DEPARTMENT OF THE TREASURY

Four bureaus in the Department of the Treasury require the services of chemists and allied workers—the Mint Bureau, the Bureau of Engraving and Printing, the Public Health Service, the Division of Customs and the Bureau of Internal Revenue. The number of such workers employed is indicated in the following report from the Department:

Designation and Number of Employees Engaged in Chemical Work in the Department of the Treasury, March 6, 1922

Position	Office	Men	Women	Total
Alloy Chemists	Division of Customs	2 (assayers)		
	Mint Bureau	12 (assayers)		14
Analyst	Division of Customs	4		
	Mint Bureau	1		5
Assistant Chemist (including assistant chemists in special lines, biochemists, etc.)	Internal Revenue	6		
	Division of Customs	1	1	
	Mint Bureau	5 (assayers)		
	Public Health Service	4		17
Chemical Engineer	Bureau of Engraving and Printing	1		1
Chemist (including chemists in special lines)	Internal Revenue	7		
	Division of Customs	10	1	
	Bureau of Engraving and Printing	2		
	Public Health Service	8		28
Chief Chemist	Division of Customs	5		5
Junior Chemist (including junior chemists in special lines)	Internal Revenue	10		
	Division of Customs	1		
	Bureau of Engraving and Printing	1		
	Public Health Service	3		15
Laboratorian	Internal Revenue	4		4
Laboratory Assistant, Helper, Inspector	Division of Customs	5		
	Bureau of Engraving and Printing	4		
	Public Health Service	41	6	56
Metallurgist	Mint Bureau	3		3
		140	8	148

Mint Bureau. For the mint, assay offices are maintained and assayers, analysts and metallurgists are employed in New York, New Orleans, Carson City, Seattle, Boise, Helena, Salt Lake City, Deadwood. There are also refineries at New York and San Francisco.

Bureau of Engraving and Printing. In the testing laboratories of the Government Printing Office there are examined samples which are submitted in connection with annual contracts, shipments made to the storekeeper, and other supplies for the General Supply Committee and for open market purchase.

Public Health Service. One of the agencies for scientific research of the Public Health Service is the Hygienic Laboratory which maintains among others a division of pharmacology and a division of chemistry. The division of pharmacology has been studying the chemotherapy of syphilis and related diseases, the chemotherapy of tuberculosis, the food value of dried milk, poisoning by T.N.T. and other explosives, hookworm remedies, etc. Numerous samples of drugs and foods are examined for various governmental agencies and private individuals, and many inquiries of a pharmacological nature are answered.

The division of chemistry has been engaged in the study of the problem of disposing of chemical wastes of industry, problems of water purification and disinfection, problems of ventilation, and the detection and estimation of poisonous nitro-compounds and of toxic impurities in arsphenamine and neoarsphenamine. Routine examinations have been made of arsenicals and therapeutic serums. Control tests, water analyses, poison determinations, and the like, are made for other Government departments also. In cooperation with the office of industrial hygiene and sanitation, analyses have been made of gases, dusts, paints, oils, glazes, inks, etc.

Special studies are frequently undertaken, such as recent field and laboratory studies into the chemical phenomena of fatigue and the study of oxidation reduction in vital processes.

The Public Health Service maintains hospitals for arriving aliens under the Division of Foreign Quarantine and Immigration. Medical examinations and hospital treatment entail a large amount of laboratory work. The laboratories do not have separate departments of chemistry, although it has been strongly recommended by officers of the Public Health Service that separate departments of bacteriology, pathology and physiological chemistry should be fully developed.

In the Division of Marine Hospitals and Relief some 62 general and special hospitals are also maintained throughout the United States for beneficiaries of the War Risk Insurance Act and of the Federal Civil Service Compensation Act, Government lighthouse service employees, the coast guard service, and seamen on merchant vessels. In practically all hospitals clinical and bacteriological laboratories are operating; very few chemists are, however, employed for purely chemical work.

Bureau of Internal Revenue. The Division of Technology of the Bureau of Internal Revenue examines thousands of formulæ of medical preparations and flavoring extracts to determine in each case whether the product manufactured or proposed to be manufactured according to these formulæ might properly be classified as non-beverage alcohol. Fermented beverages are analyzed to determine the alcoholic content.

The analysis of narcotic preparations and drugs requires exceptional care as violations of the Harrison Narcotic Law lead frequently to criminal proceedings in which the cases must be prepared from a chemical viewpoint.

In a recent year more than 18,000 samples were received and analyzed to determine the question as to their taxability under the internal revenue laws.

DEPARTMENT OF WAR

In the supplies division of the Quartermaster's Corps specifications are worked out for various commodities required by the army, and products used are standardized. The technical staff of the Ordnance Department has conducted research in various metallurgical lines and compiled general specifications for ferrous and nonferrous materials used in ordnance, and methods for testing them. In the Air Service and Engineering Department also materials used are studied and tested. Several chemists are employed in the Medical Department.

The technical division of the Chemical Warfare Service has charge of the general program for the development and testing of chemical warfare materials. There is a chemical research and development division devoted to the discovery of new toxics, the development of manufacturing methods for them and of adequate methods of defense against them.

The number of chemists and allied workers in the Department of War is reported as follows:

Designation and Number of Employees Engaged in Chemical Work in the War Department, March 3, 1922

Designations	Quartermaster's Corps	Medical Department	Ordnance Department	Air Service	Engineering Department	Chemical Warfare Service	Total
Assistant Chemist (including assistant chemists in various lines, biochemists, etc.)			7		1	1	9
Assistant Metallurgists.			1	1			2
Chemical Engineer			3			8	11
Chemist (including chemists in various lines)	4	3	12	7		14	40
Chief Chemist			1		1	1	3
Associate Chemist				1		46	47
Consulting Chemist....						1	1
Consulting Metallurgist							0
Junior chemist (including junior chemists in special lines)			1			29	30
Chemical Technologist Associate						10	10
Chemical Technologist Assistant						1	1
Chemical Technologist Junior						8	8
Laboratorian	1		1				2
Laboratory Assistant, Helper, Inspector....			29*		1	17	47
Metallurgist			5	2			7
Technical Adviser						1	1
	5	3	60	11	3	137	219*

STATE GOVERNMENT LABORATORIES

Chemists are employed in state laboratories connected with departments of health, boards of sanitary control, food and drug departments, public service commissions, and such special organizations as state water surveys, state food commissions, state institutes for the study of special diseases, etc. The administrative units vary considerably from state to state. State agricultural experiment stations have been included under the Department of Agriculture[1] with which they are affiliated, although the positions in them are under state rather than federal jurisdiction.

Boards of Health. State departments or boards of health may include among the functions of their laboratories the examination

* Of the above 219 employees, one, a laboratory helper in the Ordnance Department, is a woman.

[1] See p. 173.

of foods and drugs, the study of water and sewage, the analysis of pathological specimens, the making of vaccines and serums, the investigation for diagnostic and preventive purposes of special diseases—trachoma, cholera, etc.

The examination of foods and drugs is in a large department of health frequently assigned to a separate division or bureau. There are states also in which there is a major department of foods and drugs. The division of foods and drugs is charged with the administration of the pure food and drug law which includes inspections of dairies, groceries, bakeries, and similar food establishments. Such a division keeps in touch with all associations and organizations of food producers and manufacturers and works constructively in building up public opinion for pure food and sanitation in addition to the enforcement of existing laws. There is close cooperation with the Government laboratories in Washington.

Sarah Huntoon Vance became director of the Bureau of Food and Drugs of the Kentucky State Board of Health on her return from an appointment as chemist in the health department of the Panama Canal Zone administration. Mildred E. Hinds, who had been assistant chemist, has recently been appointed chief chemist of the Food and Drugs Department of the State of Tennessee. For ten years Sylvanna Elliott West was chemist and microscopist in the South Dakota Food and Drugs Department. In various other state laboratories women are working as chemists, bacteriologists and microanalysts.

The examination of water and sewage—the determination of hardness, of iron, of total and fixed solids, of bacteria in water; recommendations on water for drinking; research work in connection with the operation of water purification plants and with sewage sludge utilization and by-product recovery, are all functions of state boards of health. In some states there is a separate division of water and sewage in the board of health organization.

As chemists and bacteriologists women have been doing important control and research work in the laboratories and experiment stations of such divisions. There is occasionally an opportunity to combine graduate study with work in these laboratories. The practical experience gained is valuable for any food and water work, especially if there is any opportunity for research as well as routine analysis.

The analysis of pathological specimens, the making of vaccines and serums, investigation of special diseases, etc., may form the

largest part of the work of a state department of health. In this work the demand is chiefly for bacteriologists, clinical pathologists and serologists. There must also be chemists for the purely chemical work, and bacteriologists and serologists must have a background of chemistry, which they are constantly called upon to apply in this special field. Chemistry is of rapidly growing importance in diagnosis and in treatment of disease[1] and in boards of public health as in hospitals there is reason to expect increasing opportunity for the well trained physiological chemist.

It is occasionally necessary for the chemist to appear before a court with scientific evidence in cases of suspected poisoning, and the like. For this phase of the work women have seemed unsuited and there has been some hesitation, on that account, in employing them as chemists in boards of public health. As women are proving their ability to meet this requirement the prejudice is disappearing.

Dr. Florence Hulton Frankel is assistant serologist in the New York State Board of Health, where she is in charge of all serological work. In many states women are employed for work in the pathological laboratories of the department of health.

Institutions. State hospitals and other institutions have laboratories in which chemists as well as bacteriologists and clinical pathologists are employed. There are some state institutions devoted to the study of special diseases, in which there are excellent opportunities for research work for physiological chemists.

The position of dietitian for state institutions has in the past demanded primarily a practical training and experience in large quantity purchasing and planning. This is rapidly coming to be changed and the growing demand is for women trained in science and nutrition, for which the basis is chemistry.

Public Service Commissions. Chemists are employed in public service commissions for the analysis of materials purchased and used in the operations controlled by the commission, such as transit construction; such materials include a large variety—steel and iron, cement, asphalt, coal tar pitch, paints, water, etc.

MUNICIPAL GOVERNMENT LABORATORIES

Cities also have departments of health in whose laboratories chemists and bacteriologists are engaged in making cultures and examining pathological specimens, blood, sputa, discharges, etc.,

[1] See p. 21.

which are brought to the laboratories. Chemists are employed also for the examination of food and drugs. City departments of health are responsible for the purity and safety of the municipal water supply, the control of the city's milk supply, and related matters.

City hospitals have pathological laboratories in which analysts trained in chemistry and bacteriology are employed.

In some municipalities the board of health laboratories are called upon also to test materials used by other city departments, coal, cement, etc. In larger cities there are separate provisions for such testing. In a smaller town there may be one city chemist to whom all analyses for the municipal government activities come. One woman holding such a position, which requires only half time employment, describes her duties as including the examination of about 200 samples of milk per month for butter fat, solids, preservatives, etc., and the analysis of about 40 samples of water per month. She also examines a considerable quantity of various food products for standards of purity and very frequently makes poison examinations for the police department.

An assistant to a city chemist describes the work of her laboratory as including pathological work—diagnosis of diphtheria cultures, tuberculosis, etc.; the analysis of milk, butter, water, vinegar, flour, coal, and numerous other chemical analyses of products brought to the laboratory from time to time.

The position of junior chemist, which a woman has been holding in a department of health in a middle western city of about 400,000 people, has been analyzed by the city as follows: "The duties of junior chemist, which require training and experience, and involve fixed responsibility for analytical and research work, are—to have charge, under the city chemist, of analyzing milk, cream and other dairy products, water, ice, sewage, foods in general and other materials; to make analyses of city gas supply; to prepare and standardize solutions of acids, bases and salts; to prepare monthly statistical reports and maintain a file record system of general analytical results; to carry out special chemical investigations and to assist in incidental chemical and clerical work as may be required."

Chemists in city laboratories have felt unfortunate effects of politics in their work. "Unless the commissioner (of health) is of a high type, politics are apt to play a deteriorating part. Even with a splendid commissioner politics have been a disagreeable factor." "Political conditions have been most annoying and detrimental to

growth and advancement. Work for work's sake is not gratifying and enjoyable under these adverse conditions, though the experience is excellent."

At the same time women chemists recognize the great opportunity for fine service in public health work and find satisfaction in it in spite of any "adverse conditions." One such chemist says with enthusiasm, "The avenue of public service and welfare is so broad as to make one almost gasp at the enormousness of the task."

CHEMISTRY IN RELATED FIELDS

RELATED SCIENTIFIC WORK

PHARMACY

Pharmacy is a very limited special section of chemistry; it deals entirely with the compounding of drugs. Adequate preparation for pharmacy may be secured in from two to four years. Pharmacy as a vocation holds no physical handicaps or inherent limitations for women. On the other hand it offers an opportunity for an independent business and for responsible work that need never become routine because of the steady scientific development in the field.

Many hospitals employ women pharmacists. They are employed also by druggists and by various manufacturers of pharmaceutical preparations, although in this industry thoroughly trained chemists and pharmacologists are usually preferred.

The pharmaceutical chemist is the pharmacist with additional training in the chemistry of drugs. She may be a skilled prescription druggist, a teacher, or a laboratory worker in a pharmaceutical manufacturing plant.

The director of a laboratory for applied chemistry states: "Pharmaceutical chemistry is a field in which I think women will find an increasingly important place. It is a line of work which involves a certain amount of business acumen, a wide range of manufacturing applications on a scale within their physical strength and the application of artistic concepts in the creation and placement of pharmaceutical wares."

MICROSCOPY

Microscopy is increasingly used as an aid to analysis in all lines of chemistry. Photomicrography, the preparation of enlarged photographs of microscopic objects, is closely associated with chemical microscopy.

Microscopy is of increasing importance in industry. In the course of this study the need for microscopic analysis has been emphasized by representatives of laboratories in industries which produce paper, cement, canned foods, leather, metals, photographic materials, rubber and textiles.

Metallography is the microscopic study of metal structure and alloys and has become a highly important method for such study. The microscope has proved itself invaluable to the iron and steel metallurgist because of the information it discloses as to the physical structure of metals. Its extended use has been linked closely with the development of heat treatment, for only by means of the microscope can the structural changes produced by heat treatment and annealing be observed.

In the examination of foods and drugs the microscopist must be trained in botany as well as in chemistry and microscopy. Several women so prepared are employed in the food and drug departments of the Bureau of Chemistry.

Chemical microscopy is by many considered to be one of the most promising fields for women and one in which they are peculiarly adapted to succeed. An industrial chemist of extensive experience has found that "there are very few men who are broadly trained in this department of chemistry and fewer still who stand out as specialists, except perhaps in the field of metallography. Well trained and expert chemical microscopists could be utilized to great advantage in many lines of industry and by proper specialization and some original work it should be comparatively easy for a woman to secure recognition as an expert or to develop a business of her own if she so desires. In that event the expense of office and laboratory equipment would be only a very small fraction of that required for a laboratory of the usual type."

ASSAYING

The assayer is an analyst whose work is confined to metals and their ores. The usual duties of an assayer, the determination of the amounts of one or more ingredients of ores, metals or alloys, can be learned by experience and with only a fair amount of training in chemistry.

METALLURGY

Metallurgy involves not only a thoroughgoing scientific knowledge of metals and their ores but an equal expertness in the art of preparing metals from their ores. The metallurgist, therefore,

knows the physical and chemical properties of ores, metals, fuels, refractory materials, etc., understands the conditions of manufacture of metals whether the process be roasting, smelting, amalgamating, leaching or electrolysis, and knows how to control every manufacturing operation, as well as how to test the product. The metallurgist may be an expert in iron and steel, in non-ferrous metals and their alloys, or in precious metals.

BACTERIOLOGY

For work in bacteriology a thorough preparation in chemistry is increasingly necessary. In various instances women trained in chemistry have entered laboratories where bacteriology or a combination of chemistry and bacteriology is required, and have learned in the position itself the additional technique necessary.

PLANT PHYSIOLOGY

Plant physiology is a science requiring chemistry and physics as well as botany. The study of plant life from the chemical point of view is in its infancy. Few botanists have known chemistry and few chemists botany. In the combination of the two there is promise of considerable future development. A well-trained chemist might transfer to the field of plant physiology without knowing the whole field of botany.

DIETETICS

The terms dietetics and dietitian have not been standardized and designate now a practical managing housekeeper and again an expert in nutrition. With the growing recognition and knowledge of the scientific aspects of foods, not only in illness but in health, and an awakening interest in proper feeding, there is increasing opportunity for the *biochemist* to be employed as a scientific dietitian in a hospital to work with the doctor on diet cases; in public institutions and schools to plan and direct the purchase and preparation of foods; with boards of education or boards of health to teach nutrition popularly to adults and children; in the extension service of state agricultural colleges, and in social agencies.

There is considerable opportunity for the well-trained woman who understands the principles of nutrition as well as buying, cooking and the management of employees, to go into dietetics and standardize it from the inside.

CHEMISTRY IN OTHER FIELDS

LIBRARY WORK

The special library[1] of the research laboratory or of the industrial plant whose processes are extensively chemical ones, requires a librarian with at least some training in science. Such a library becomes a reference center for the scientist in search of new methods, as well as for the manufacturing expert, the business manager or the efficiency engineer, and it must be built up by one who understands what knowledge should be collected and distributed for the development of the industry.

"The special library fails altogether to attain its full capacity for service if it functions as a repository for facts, however carefully its material may be classified and arranged. Its higher service may be measured by the aggressiveness with which it reaches out for information, the discretion with which it evaluates the material so secured, and above all, by the promptness and certitude with which the information in readily available form is brought to the notice of those who may need it." [2]

In many cases the librarian also makes abstracts of technical and chemical publications and of patents. Sometimes the librarian is rather a versatile secretary. One industry, for instance, reports that its laboratory records, files, books, etc., are cared for by a woman conversant with chemical terms and able to do stenography, typing, filing, etc.

ABSTRACTING

A usual feature of the service of a technical library is the monthly compilation of abstracts of periodical literature bearing on the subjects in which the various departments of the industry and laboratory are concerned. Abstracters are also employed occasionally in plants in which there is no library, and by technical journals.

An abstracter of chemical literature in an industrial plant recommends as preparation for such work a course which has chemistry as its major and at least elementary training in biology, geology, mineralogy and chemical engineering. It is in some cases considered that a man with a knowledge of machinery and of the factory problems can give a clearer interpretation of the books and articles

[1] See Special Libraries, May, 1919, a number devoted to library science in the service of chemistry.

[2] Arthur D. Little, in Special Libraries, May, 1919.

abstracted. There must in any case be close cooperation between the plant and the abstracter, who should have a fair knowledge of the research being carried on and the equipment and general problems of the chemical laboratory.

The abstracter must be able easily to use clear concise English, and readily to read French and German.

SCIENTIFIC JOURNALISM

Some industries publish abstract bulletins and other material regularly for their employees, of which the editorial work is frequently done by women. The work of one woman, for example, includes the editing of an abstract bulletin which is printed twice a month and of a patent bulletin and list of books mentioned in journals, issued twice a month. She assigns articles to be abstracted and calls the particular attention of staff members to articles appearing in current periodicals. She finds necessary for her work thorough training in chemistry, in foreign languages and in English.

There is an increasing number of technical journals, the editorial work of which would seem to offer attractive positions for scientifically trained women. Such work with the exception of the position of editor is still too frequently in the hands of clerical assistants without scientific knowledge. There are, however, exceptions. For instance, a woman with experience in chemical research recently entered an editorial position on a chemical journal where her work was almost entirely the preparation of accepted manuscripts for publication.

There is an occasional opportunity also, for a person trained in science, on the staff of a non-technical periodical, for the supervision of food advertisements, for example.

A university position in chemistry which includes some editorial work is described by the woman holding it as "principally keeping track of the literature that comes out in our line, abstracting or translating parts and making a card index, also editorial work for the division, some writing of articles and collecting material on specific subjects as there is occasion. I have just completed for publication an extended bibliography."

SECRETARIAL WORK

The work of a secretary varies with each position. Secretaries with training in chemistry are frequently required in laboratories,

for work with individual chemists or with physicians and groups of physicians, or as secretaries to executives in industries who deal with chemical matters. A secretary with training in chemistry may do some abstracting and some editorial work in connection with certain clerical duties.

An officer of a chemical manufacturing company considers that technical secretarial work includes abstracting of chemical literature, compiling reports from abstracts and from laboratory progress reports, compiling data from log sheets showing the daily operation of work in the plant; and in a general way handling routine matters arising in connection with the administration of a laboratory.

For this work there is recommended a thorough knowledge of chemistry, a fair knowledge of mathematics with the ability to use a slide rule, a reading knowledge of French and German as well as training in stenography and typewriting. A knowledge of library system would be very valuable and a thorough course in the fundamentals of economics and social science goes without saying for industrial work of any kind.

One industrial firm seeking a "technical secretary" has prescribed that she must be a college graduate with maximum training in chemistry and moderate stenographic ability. The position with this firm involves a certain amount of calculation of data, writing reports and handling technical correspondence. In other firms the requirements are primarily competency in stenography and typing and such familiarity with chemical subjects as would not require long training in the science itself.

One woman who holds such a secretarial position is in charge of the routine clerical work in connection with the running of a division consisting of some sixty chemists. "My personal work is for the most part proofreading letters and formal research reports, all compositions going out over my desk. It is necessary in almost all cases to edit the writings of the average chemist for grammar, conversation, vagueness of expression, etc., and to bring them into the regular form for report or letter adopted by this company."

TRANSLATING

In isolated instances women have been employed to translate research literature chiefly from French and German. Usually such translation is combined with abstracting, library work or general editorial or clerical work.

PURCHASING AND SELLING

As purchasing agents for chemical laboratories women have already well established their worth. Training in the chemical laboratory is considered excellent preparation also for work in the purchasing department of an industry in which a knowledge of materials is essential for judgment in selection. New members of the purchasing department are often selected from chemists in the analytical laboratory.

Similarly, a chemical knowledge of materials is an advantage to the person who sells them. To know the wares adequately is the most valuable element in the equipment of a sales person.

PART III

TRAINING

For any work in chemistry the need today for superior training cannot be overestimated. In the minds of leading scientists a question of greatest moment is the provision for adequate teachers of chemistry. Employers of chemists in industry increasingly emphasize the importance of adequate training and the relation between training and progress in this field. In physiological chemistry the need for adequately trained research workers is not supplied.

Superior training is especially to be emphasized in view of the fact that there is great numerical competition in this field as a result of the employment, under the pressure of war-time needs, of many so-called "chemists" who have since been applying for similar work.

In 1919 when many of these demobilized chemists were seeking employment, an analysis[1] of 576 recent registrants at the employment bureau of the Chemists' Club revealed that

29 had taken the doctor's degree
50 had taken the master's degree
70 had taken postgraduate work but no higher degree
232 had taken the bachelor's degree or the chemical engineer's degree
129 were undergraduates
53 had completed technical courses in vocational schools
13 had completed only a high school education.

Few cared to consider analytical work, but all desired research work, plant work, or business openings. Practically none desired to teach.

It was very evident that the large majority of these unemployed were not trained for the work they desired. A veritable campaign was started to urge them to return to the colleges and universities to complete their training no matter how great the burden or sacrifice might be—not to be satisfied simply with the bachelor's degree.

It is in general true that women have advanced according to their preparation, although there is still prejudice against them in

[1] Journal of Industrial and Engineering Chemistry, February, 1919.

chemistry as a vocation, and although there may be definite limitations to their progress in some lines. "There are not many first class positions open to women in pure chemistry, but at present there are as many as there are applicants," writes a teacher of chemistry, and the evidence supports this statement in general.

Of 225 women chemists who reported in full concerning their work and training for this study the classification according to academic degree and kind of position is as follows:

Academic Degrees and Occupation of 225 Women Chemists

Educational Institutions

Schools	Number of teachers of chemistry with academic Degrees						
	B.S.	A.B.	M.S.	M.A.	Ph.D.	M.D.	Total
High School	2		3	1			6
College	3	2	1	6	6		18
University		2*		3	7		12
Vocational and Professional Schools	1	2	3	8	7	1	22
	6	6	7	18	20	1	58

Industrial Laboratories

Position	Degree						
	Ph.G.	B.S.	A.B.	M.S.	M.A.	Ph.D.	Total
Analyst, Assistant, Chemist	3	19	32	1			55
Research Chemist		2	7	1	3	1	14
Head of a Division		1	4	2	3		10
Chief Chemist		2	1	2		1	6
Asst. Chief Chemist			2			1	3
	3	24	46	6	6	3	88

Laboratories for Medical or Related Analysis and Research

Position	Degree						
	B.S.	A.B.	M.S.	M.A.	Ph.D.	M.D.	Total
Technician or Assistant	4	9		1			14
Chemist	3	7	1	1	1		13
Clinical Pathologist	1	4			1	1	7
Research Chemist	5	3		1	2	1	12
	13	23	1	3	4	2	46

Government Laboratories

Position	Degree					
	B.S.	A.B.	M.S.	M.A.	Ph.D.	Total
Analytical chemist or bacteriologist	5	7	3	4	1	20
Research chemist			1		1	2
Director of Bureau			2			2
	5	7	6	4	2	24

* Both of these women were studying for an advanced degree.

Chemistry in Related Fields

Position	Degree					
	B.S.	A.B.	M.S.	M.A.	Ph.D.	Total
Translator					1	1
Literary research		1		1		2
Editor	1	1	1			3
Abstracter	1					1
Secretary	1	1				2
	3	3	1	1	1	9

The very general criticism of college training in chemistry today as expressed in technical journals, in the discussions of the section of chemical education of the American Chemical Society and in statements of various chemists, is that it lacks in *thoroughness.* Students must be taught fundamental principles and methods, seriousness must be promoted; to this there is general agreement. Whether the training of any college possesses or lacks this requisite quality cannot be judged from the catalogue description of courses, but depends entirely upon the qualifications of the teaching staff.

Other criticisms are that too much emphasis is laid on stated requirements, too little on original thinking; that the *best* teachers are not, as they should be, assigned to the teaching of Freshmen; that the research spirit is not fostered, as it should be, even though undergraduate work in itself is not adequate preparation; that the literature of chemistry is neglected; that America's contribution to the development of chemistry is insufficiently emphasized.

An inquiry[1] to which some 35 leading commercial organizations replied, as to defects found among the chemists in their organization other than personal qualities not likely to be affected by education, resulted in the following grouping of such training defects:

1. Those which can be corrected within the limit of time now given to training. They are:

(a) The young graduate cannot evaluate measurements. This means, the young chemist does not understand that a rapid qualitative reaction may have a greater value in some circumstances than a more accurate and painstaking analysis.

(b) Ability to represent experimental data graphically is lacking.

(c) There is carelessness in handling apparatus, especially sensitive instruments.

[1] Edward Ellery—The Training of the Chemist, Journal of Industrial and Engineering Chemistry, April, 1919.

(d) Notes are inadequate, insufficient and unenlightening—sometimes even untrustworthy.
(e) The young graduate is contented to get only the data asked for and seldom goes beyond that point.
(f) There is a deficiency in mathematical accuracy. More stoichiometry should be given.
(g) The foundation in theory is often poorly laid.
(h) The young graduate lacks concentration, is either indifferent or lazy.

2. Those defects which can be corrected by an extension of time given to training either from 9 to 11 months for the year or from 4 to 5 or 6 years or by a combination of the two. Such defects are:

(a) The student learns nothing from unsuccessful experiments.
(b) The English is defective. The great majority of employing chemists deplore the inability of young chemists either to express themselves clearly in spoken English or to present an easily readable written report.
(c) There is a decided lack of independence and initiative; too much assistance is required.
(d) Students should have more "brain exercise and schemes to get them on the alert should constantly be tried."
(e) The young graduate does not do sufficient reading on the side. He is more eager to take directions through his ear than through his eye.
(f) The usual course gives too much analytical work and too little constructive work.
(g) The lack of imagination is emphasized by over half of the replies. One chemist asks, "Can't there be a course in chemical imagination?"

3. Those defects entirely outside of the control of teachers and to a large extent of the institutions with which they are connected, such as the lack of practical experience. Almost 95 per cent of the replies stated that the student does not know how to apply practically what he has learned during his course. It is granted, however, that educational institutions can give only to a very limited extent practice in actual chemical processes that are commercial.

These criticisms are applied to the training of men and women. Both employers and women chemists themselves point out as shortcomings applying particularly to the training of *women* that it is weak in mathematics; that it has not equipped them with the kind of general knowledge of materials and construction that most men

have; that it has not been conducive to the development of originality, and on the other hand, that it does not develop the habit of digesting the whys and wherefores before jumping at conclusions.

Certain employers and also some women chemists criticize particularly the training given in women's colleges. There is little agreement among the adverse comments and they are seldom concrete. Some of the considerations most often expressed are that the courses in women's colleges are in general less rigid, less far-reaching, more informational than conducive to the development of original thought; that there is insufficient training in quantitative analysis in comparison with the fact that the majority of openings for women have been in analytical work; that employers are less familiar with the products of women's colleges and that a degree from such a college is therefore not so adequate an introduction as is that from institutions whose students have long been accepted in practical work; training in a coeducational institution is better preparation for working with men in commercial laboratories.

The following comments of chemists are quoted as characteristic expressions of very generally prevailing opinions concerning the value of excellent and well-rounded training in this field. A leading physiological chemist insists that "the student of chemistry whether woman or man, graduate or undergraduate, should be encouraged to think primarily of the importance of the most thorough training possible so that she or he will be prepared to make the best use of the opportunities which are to come later, rather than to try to guess too far in advance what these opportunities are likely to be and train toward them too narrowly."

From a large chemical manufacturing company come these statements: "Positions in our laboratories vary from those of simple routine testing for which a high school training would be sufficient for the best quality of work to difficult research work for which a Ph.D. in chemistry at the best universities or technical schools is none too good preparation, aside from years of experience in the actual work of the company."

(*Manager of laboratory in which four women chemists have been employed.*)

"There is probably a large over-supply of chemists at present on account of the stimulation caused by the war to chemical industry and the fact that many of those were directly connected with the making of munitions. Even when business again becomes normal, no doubt many of these will be obliged to find other lines of employment. There will, therefore, be a selection by the industries of those chemists with the best training and widest experience

and for research on the fundamental problems of the industry those who in addition to the right training have a natural aptitude for research."

(Assistant chief chemist.)

The corroborating statement from a packing house is: "I have said that the future demand for chemists in our field will always be constant; it will be constant for highly trained chemists, i. e., those who by training and temperament will have the vision to see and work out the problems above indicated."

(Superintendent of laboratories.)

A large soap manufacturing company is convinced, on the basis of its experience, that "A poorly trained woman chemist is considerably less useful to us than a man possessing just the same amount of training. In this case a poorly trained woman seems to lack the initiative, the capacity to take responsibility and the power of clear thinking that a man possesses. We would, therefore, urge whenever a woman plans to take up chemistry as a profession that she obtain a thorough chemical education, such as any of our leading universities offer. We would urge the same advice to a man, but we believe it is more necessary for a woman."

(Chief chemist in whose laboratory two women chemists have been employed.)

In an important plant for the manufacture of electrical equipment the policy is stated to be: "We make the work fit the training with everyone. The better the training the better the work, the higher the salary, and the greater the chance."

(Chief chemist in whose laboratories a small number of women chemists have been employed for about 20 years.)

Early in the year 1917 when the supply of chemists scarcely met the demand for their services, one of the manufacturing companies which for the first time were ready to take women chemists into their laboratories, sent out to colleges and employment bureaus a call for a woman analytical chemist. Her duties would be to make quantitative analyses of chemicals used in the plant, to suggest and supervise ways of removing impurities and eventually to do research work with a view to improving the manufacturing methods. As a means of eliminating the most inefficient this employer prepared a set of eight problems, covering in general the scope of the regular work of the plant and involving no chemical knowledge beyond that expected of a student who had taken the usual course. No one of the candidates answered all the questions correctly, few answered half and some failed entirely. A man was later secured

for the position. The employer's interpretation of the failure of the women applicants was this:

"They were excellently trained and knew a great deal about chemistry, but they were weak in mathematics and were unable to suggest methods which differed from the text-book training. There were several of my questions which were designed to draw out this point, and in every case without exception, the usual text-book method was employed, when it seems to me it should have been obvious that there was a much more simple and direct way of accomplishing the results. The text-book method would be utterly impossible with large quantities of material. . . .

"I don't mean now to say that there are no such things as good women chemists because we all know that there are, but I am inclined to believe that they are handicapped in two ways:

"First, by lack of mathematical training, and second, by a tendency to jump at conclusions without digesting fully the whys and wherefores. Women as a general thing are not as well trained as men to question the truth of conclusions."

Constructively, the training to which a woman should look forward for work in chemistry will be based upon an undergraduate course which gives the required thorough training in fundamentals; graduate work in chemistry, determined by the requirements of the field chosen for special work; and practical experience.

UNDERGRADUATE TRAINING

With no more than an undergraduate training, whether with the A.B. or B.S. degree, a candidate may enter high-school teaching, or may become an assistant in a college or university laboratory or be employed as an assistant in research. In industry she may enter the analytical laboratory. She may become a technician or assistant in a hospital laboratory, in rarer instances an assistant in a research laboratory. She is eligible for a beginning position in a Government laboratory. *For advancement further training is necessary.*

Many considerations enter into the selection of an undergraduate course with a major in chemistry. In all fields there is a growing emphasis on a broad general training and any specialization during secondary school or the first two years of college is discouraged.

Because of this increasing recognition of the value of a broad general training, the college course leading to an A.B. degree with a major in chemistry has advantages over the course leading to the B.S. degree in chemistry. In the latter course specialization during

the first two years is also more and more discouraged and as much general work as possible is introduced. Many more hours of chemistry are usually included, however, than are permitted in a course leading to the A.B. degree, and some work in mechanics and in the elements of engineering is introduced, or, in schools of agriculture and home economics, practical courses in these fields. There is less time, therefore, for English, economics, history, and all the subjects which make for a broad background.

English is strongly urged as an absolutely essential element of the chemist's equipment. It is impossible to do successful work without the ability to express ideas and results clearly and accurately.

The same disadvantages which adhere to the course leading to the B.S. in chemistry apply also to the courses in chemical engineering[1] which have been organized in various universities to meet the demand for technically trained workers who shall understand the chemistry involved in industrial processes and at the same time have the practical mechanical and engineering knowledge necessary for executive work in the production department of industry.

The course in chemical engineering "aims to give a foundation for work in any line of manufacture involving chemical reactions such as research, designing apparatus or laying out and operating a plant."[2]

"The course in chemical engineering is designed to give the student a thorough foundation in chemistry and in the elements of mechanical and electrical engineering, followed by training in the special field of chemical engineering, i. e., in the solution of the engineering problems of chemical industry."[3]

These two quotations serve to indicate what is the basis upon which courses in chemical engineering are organized. They are naturally crowded since they combine work in two scientific fields and institutions in which they are offered commonly urge their students to continue with graduate work after completing such a course.

The arts and science college not associated with a university has obvious advantages for the young student in the way of college life. In the college, also, the most important members of the department staff are teaching undergraduates. There is danger, on the other hand, that equipment may be limited and the spirit of research, so essential to inspiring teaching, lacking. The undergraduate department of a university offers the advantage of the

[1] See Appendix for list of schools offering such courses.
[2] Carnegie Institute of Technology, Bulletin 1920-1921.
[3] Massachusetts Institute of Technology, Bulletin 1921.

stimulus derived from contact with the advanced work and research of the graduate department, and a larger choice of courses. The chief limitation lies in the fact that undergraduates are often taught entirely by junior members of the teaching staff.

Since the quality of the work depends primarily on the character of the teaching, catalogue descriptions offer little help in making a choice of schools. The test of a good department of chemistry is not so much the adequacy of equipment or the number of students enrolled, as it is the quality of the teaching and the number of students who are inspired by the work of the department with the deep interest in chemistry that carries them on into graduate study.

Whether the prospective chemist will work in educational institutions, in industrial laboratories, in laboratories for medical analysis and research or in Government laboratories, there are certain common elements requisite in undergraduate training in addition to the broad background which is universally conceded to be of primary importance.

1. *Thorough fundamental training in chemistry,* which would include inorganic, organic and physical chemistry with courses in qualitative and quantitative analysis, is essential. While immense pressure is brought to bear upon the arts and science college to introduce "practical" or "applied" courses, and while many colleges have introduced such courses as gas analysis, water analysis, food chemistry, sanitary chemistry, soil chemistry, industrial chemistry and the like, for the advantage of students who desire to prepare for a special kind of work, or such courses as chemistry in its applications to daily life or applications to civic problems, for the advantage of students who desire or need mainly to be informed about chemistry, the growing consensus of opinion in industry and in educational institutions is that the real function of the college course in chemistry is to lay the broad foundation upon which both success in chemical work and in further study and research in chemistry depend.

In the course of an inquiry into the position of natural science in the educational system of Great Britain, conducted by a special committee appointed by the Prime Minister, it was found that chemical manufacturers laid special stress on the value of general chemical education rather than on the possession of detailed knowledge of the particular processes of the factory, since the increasing subdivisions of the industry and the rapid development taking place in all its branches reduce the value of the mere acquisition of

knowledge but increase the value of the personal qualities of judgment, accuracy, understanding and insight. The prevailing opinion was that special training is best given at the works and that the time needed before a worker becomes of use to his employer will be shortened by thorough chemical training.[1]

The following comments in regard to training from chemists of experience are illustrative of the general conviction that fundamental courses in chemistry should make up the undergraduate training in the science:

"A good foundation in general inorganic and organic chemistry, methods of quantitative and qualitative analysis, organic as well as inorganic, and as much physical chemistry as can be included."
(Woman chemist in a printing, dyeing and bleaching factory.)

"Courses in inorganic, qualitative and quantitative chemistry given with a view to developing independent thought, making the student thoroughly conversant with chemical literature and so able to select her own methods."
(Woman analyst in a plant manufacturing heavy chemicals.)

"Thorough grounding in chemical principles rather than the so-called industrial and applied courses in chemistry offered in many colleges." *(Woman research assistant in a yeast manufacturing company.)*

"Theoretical courses. A good course in chemistry with all the emphasis on theory and very little on application courses."
(Woman executive office supervisor of dyestuffs technical laboratory in a large manufacturing company.)

"A thorough knowledge of chemistry, not special branches but chemistry in general. You specialize in each particular position."
(Woman analyst and research chemist, Bureau of Standards.)

"As thorough intensive and extensive training as possible in all branches of chemistry and related sciences. Of course some particular lines will appeal for research and chief interest."
(Professor of chemistry in a women's college.)

"Either a thorough general chemical education or else no chemistry at all." *(Chief chemist in a chemical industry in which no women have been employed.)*

2. In all fields there is emphasis on the need for a *knowledge of the related sciences,* mathematics, physics and biology, not only in themselves but in their relations to each other and to chemistry. The following quotations are selected from many similar ones:

[1] Natural Science Teaching in Great Britain, United States Bureau of Education, Bulletin, 1919, No. 63.

"Advanced training in mathematics—calculus and geometry, thorough grounding in physical chemistry, physics, some biology, organic chemistry, and qualitative and quantitative analysis."

(Woman chemist in the analytical laboratory of a company manufacturing electrical equipment.)

"A girl in preparing for work in chemistry should have a thorough knowledge of mathematics, physics and chemistry."

(Chief chemist in a plant manufacturing dyestuffs, in which several women are employed for control and research work.)

"A thorough training in chemistry, especially in physical chemistry and thermodynamics, also differential and integral calculus and a good general course in physics."

(Woman physical chemist in research laboratories of kodak manufacturing company.)

For work in physiological chemistry, training in physics and mathematics is becoming more and more important even though biology and physiology are the sciences more immediately related to this field. The following advice as to training comes from physiological chemists:

"Thorough foundation in chemistry, mathematics and physics."

(Woman assistant serologist in a state board of health laboratory.)

"Thorough foundation in the principles of chemistry and stoichiometry, physics, mathematics, botany, histology and bacteriology. Mathematics is very essential."

(Woman chemist and microscopist in a state food and drug department.)

"The title of chemist presupposes in this day a very substantial foundation in physical science also, so much so that an undergraduate course in college would scarcely allow of its acquisition along with the necessary chemistry courses. When preparation is insufficient, opportunities for advancement are correspondingly reduced."

(Woman research chemist in a surgeon's laboratory.)

"A thorough grounding in physics, chemistry and mathematics, also as much general scientific knowledge as possible. I have had occasion to apply absolutely everything I have ever learned, in the course of my work, although of course as an organic chemist, I suppose I have used more organic chemistry than anything else."

(Woman chemist in an institute for medical research.)

"A thorough working knowledge of pure physical chemistry and higher mathematics (calculus and advanced mathematics)."

(Woman research assistant in a school of public health.)

"If I had my college course to do over I would take more botany, zoology, physics, and be able to read German very readily."
(*Woman assistant chemist in an agricultural experiment station.*)

From women teachers of chemistry come like statements:

"A solid foundation in chemistry, physics, mathematics."
(*Instructor in chemistry in a state agricultural college.*)

"More mathematics, more physics for the future chemist."
(*University instructor and chemist in research.*)

"A good knowledge of German, French, mathematics and physics as well as chemistry." (*Assistant professor in a university.*)

"More chemistry in college and also be better grounded in physics and bacteriology. More French and German as an undergraduate." (*Teacher of chemistry in a medical school.*)

"Thorough training in the fundamental courses in chemistry, mathematics and physics."
(*Assistant professor of inorganic chemistry in a state university.*)

"Courses in pure chemistry and physics as well as physiological chemistry."
(*Associate professor of household economics in a state university.*)

In view of the fact that many scientific workers are at some time or other handicapped by not being sufficiently familiar with the methods and theories of the fundamentally important science of physics, the suggestion has been made[1] that a course in physics, organized so as to develop its applications to the chemical, biological, and medical sciences be offered, preferably in the senior college year, to give those principles and measurements which are known to be fundamental in the kinds of work which might be expected to follow.

3. Training in chemistry should include the giving of some *information concerning the achievements and present applications of the science.*

Information as to the practical applications of chemistry in industry, agriculture, medicine, etc., may supplement regular courses in chemistry. It is made more concrete and vivid by visits to various laboratories and industrial plants. It has been suggested that the motion picture be used to connect instruction in chemistry with its industrial applications. Many industries are prepared to loan films showing the operations of their plants.

[1] Paul E. Klopsteg. A Plea for Courses in Physical Measurements for Students of Chemistry and Related Sciences. Science, v. 50, p. 199.

The possibilities of cooperation between schools and industry are just beginning to be realized in this country. There is a growing conviction that the schools must keep in closer touch with industry, and on the other hand, that industry depends upon science both for efficient production and for development, hence must assume a larger share of the burden for the technical training of the future.

Various steps have been taken for establishing practical means for such cooperation. In the chemical engineering courses of various technical schools, work in industrial establishments is a part of the training, in some cases in the senior year, in others earlier; this is particularly true in those schools which have established a cooperative course requiring a regular alternation of study in college and work in industry. Several industries offer students summer employment which provides a highly desirable arrangement for acquiring some understanding of the practical applications of theory.

Schools have also formulated plans by which students may secure some practical experience with industry through vacation work, inspection visits, attendance at weekly colloquia for workmen, and the like. Industries, on the other hand, plan the work of inexperienced graduates whom they take on in such a way that it shall serve as continued training.

Industrial establishments in some instances have endowed special lines of research in various universities either in the form of fellowships or of funds with which to provide personnel and equipment for such research. Trade associations representing groups of industries are in some instances also supporting research in this way. University teachers are frequently invited to collaborate with research that is initiated in industrial laboratories.

Some universities offer a consulting service for industries which may or may not be directly supported, at least in part, by the industries which submit practical problems to be worked out in the university laboratories.

4. Training in chemistry, since the literature of the science has become so vast that it can scarcely be covered by one person, must include some *instruction in the use of a library* and some acquaintance with journals (trade and technical publications), reference books and methods of finding all that is known of a particular substance or process.

Several universities have introduced special courses in the use of the literature—sources of information and how to use them in

the library, and the use of current periodicals. Others prefer to make such instruction incidental to regular courses in chemistry.

5. *A reading knowledge of German* is absolutely necessary, and *of French* very desirable for any work in chemistry.

GRADUATE TRAINING

For progress in work in chemistry it is generally necessary to plan for graduate study. This is increasingly true because of the extensive development of the science in modern times and because the period of economic depression has brought a new evaluation of the chemist and a discrimination strongly in favor of the best-trained workers available. It is generally agreed that while there is danger of an over-production of so-called chemists, there will never be too many *good chemists*. The most promising candidates for the Ph.D. degree are profoundly impressed with the extensiveness of the field and their own small equipment for it.

Comments of women chemists indicate agreement as to the value of advanced study.

"I should strongly advise any woman to take whatever extra advanced work she can secure. I have so advised many friends. It has paid me in itself, made me a broader and wiser woman, and brought money returns also."

(Chemist in Bureau of Chemistry since 1902.)

"An advanced degree is necessary, and graduate training should immediately follow undergraduate; but it is important to get it at any time. One must be alert to take advantage of special courses, watch one's education for weaknesses and build up here and there."

(Assistant to the superintendent of a pharmaceutical manufacturing company.)

"The Ph.D. is not necessary, but for advancement to a position of large responsibilities an equivalent amount of knowledge and experience *is* necessary."

(Research chemist in an industry which produces chemicals for the textile and leather trades.)

"The research laboratory has far more to offer a woman who has sufficiently good training. The average college graduate has not. She has not gone far enough nor has her work been rigorous enough."

(Specialist in technical literature in a company manufacturing electrical equipment.)

"Far better positions are open to the Ph.D. than to those with less training."

(Research chemist in kodak manufacturing company.)

Employers regret that women chemists "do not take their work seriously enough and therefore do not make a consistent effort to extend their knowledge in order that they may fit themselves for more advanced work."

(Chief of employment division in a zinc manufacturing company in which six women chemists have been employed.)

The qualities possessed by the Ph.D. which are not and cannot be a part of the equipment of the B.S. or B.A. have been summarized briefly as follows:

1. The person who has had several years of research training has developed a self-reliant spirit of investigation which can result only from actual experience in attacking vigorously an unsolved problem. The independence, ingenuity, and resourcefulness gained by the student in such research work cannot be too highly valued.
2. The person trained in chemical research has a knowledge and understanding of the methods of attack of an original problem along chemical lines. One important part of the research chemist's training is that having to do with the use of chemical literature. The ability to make full and critical use of such literature, the power to select the correct methods, to develop original work—these are some of the fruits of thorough training.
3. There is a distinct stimulus which comes to the graduate student from association with teachers who are themselves thoroughbreds in scientific research. The undergraduate does not come into close touch with the instructor but the graduate student does, for the painstaking direction of research by the teacher can only be done by exceedingly close supervision of the student's work on the instructor's part.

Since the advanced positions open to women today are chiefly those demanding research ability, and since it is unanimously acknowledged that for research work the preparation leading to the doctor's degree is essential, it is particularly urgent that *women* who choose to make chemistry their profession should by all means secure graduate training.

The proportion of women who have taken an advanced degree is as yet small but is increasing. Of some 660 women listed in the course of this study, 87 have completed the work for the Ph.D., 53

have taken an M.A. or an M.S. Many others have secured graduate training without completing the requirements for an advanced degree, not only in American universities, but in Germany and England also. Sir William Ramsay expressed high regard for the character of the work which Anne Flanigan did as a student in his laboratory.

There are various opportunities for combining practical work in a salaried position with graduate study[1] in educational institutions. In schools of agriculture, schools of home economics, medical schools, schools of public health and in graduate departments of chemistry there are some paid research assistants who may secure for their results academic credit and pursue their own study while they are employed.

The work done in recognized institutes for research may also be credited and may develop into a thesis acceptable in applying for the doctorate.

Theses may be worked out in industrial research laboratories. Industries not only give students employment during the summer months, but in some cases place them on salary in special schools after the undergraduate work is completed.

Various government departments have inaugurated a system of advanced instruction in scientific and technical subjects related to the work of the department in which adequate instruction is not available in Washington; for chemistry, this is true of the Bureau of Standards and the Department of Agriculture.

The person with whom one studies is the chief factor in graduate training. It is important to plan to study with the leaders in the special field chosen. It is generally advisable to begin graduate study at once although judgment varies as to this plan. In one important industrial laboratory the director "recognizes ability with or without a degree. A degree as such carries no weight here. Study during work hours is encouraged at all times. The feeling of the laboratory is that work toward a Ph.D. is taken more profitably after a student has been employed long enough to find out in what branch he is most interested." Some positions would offer work broad enough to be helpful in discovering such interest, a more limited position would not.

The vocational requirements of the work in educational institutions, in medical laboratories, and in industry would seem to offer considerations of importance in planning graduate study; experience is proving the necessity, however, of devoting the graduate years to pure chemistry rather than to its applications.

[1] See Appendix for list of fellowships available.

CONSIDERATIONS PERTAINING TO SPECIAL FIELDS OF WORK

Educational Institutions. For high school teaching the law in many states requires a certain amount of preparation in the theory and methods of education. A specialist in public school administration expresses emphatically his conception of the value of such preparation as follows:

"The problem involved is not as much one of supply and demand as it is of securing teachers who are adequately trained in the theory and practice of education, as well as in the field of chemistry. Most chemistry teachers are limited in their knowledge of educational theory and practice in such a degree that they can be easily supplanted by those women who supplement their knowledge and skill in the field of chemistry with the proper professional background."

While no such requirement pertains in college and university teaching, and while thorough grounding in the subject to be taught will always be the primary requisite, there is recognition of the value of training in psychology and in the philosophy of education.

A number of women who have had experience in industrial laboratories before entering teaching consider such experience extremely valuable preparation, because of the insight gained into the applications of chemistry, and the relation between "school methods and the more speedy commercial methods."

Graduate work in physiological chemistry is the requisite preparation for teaching the subject in schools of medicine or public health and in schools of home economics; some training in the practical preparation of foods should be added to the specialized training in chemistry for teaching or special work in nutrition in schools of home economics.

Medical Laboratories. For work in laboratories for medical and related analysis and research, physiological chemistry is the line of specialization. Short courses are offered in various hospital laboratories which prepare the high school graduate for the position of technician. For scientific work in this field the need for long preparation in chemistry and related sciences has already been pointed out.[1] The advice of several leading physiological chemists may be briefly summarized as follows:

A broad foundation in the fundamental theory and practice

[1] See pp. 32, 33.

of chemistry, in physics and mathematics must first be laid, with at least an elementary biological training. After college, training in a hospital laboratory is advised, preferably one connected with a medical school where the clinical methods will be taught and where the student may see the application of her chemistry knowledge, and the relation of her work to medicine. This will give her a broad view. Special methods courses in college are not advisable. Graduate work should be in chemistry rather than in medicine. Progress to advanced fields of work necessitates a broad outlook and appreciation of the problems of physiological chemistry, and a long apprenticeship in preparation.

The following statement of a professor of physiological chemistry is characteristic of the general judgment concerning the value of advanced training for work in this field.

"In my opinion it is a very desirable investment on the part of a prospective chemist to carry his or her training as far as possible beyond the point necessary merely to obtain a position. While advanced training might not make a great difference at the start, I think that it usually does make a great difference in the subsequent rate of professional progress; and particularly in the opportunities for promotion from routine work to work of a more interesting kind."

Industrial Laboratories. Students looking forward to work in industrial laboratories are apt to desire special courses in industrial chemistry. This is coming to be considered a short-sighted policy. It has been pointed out[1] that chemists find fundamental courses of superior practical value. Gas analysis, for example, is simply an application of quantitative analysis and students who have mastered the principles of the larger subject should be able to learn to apply them to a specialized one without taking a formal course in that subject. It is impossible to foresee what practical applications will be required in any one experience. The following statement of an employer in a chemical industry expresses a general preference that the practical training of the beginner be left to industry itself, which changes so rapidly that it is impossible to expect schools to teach modern methods of procedure in detail.

"No *special* preparation would be necessary outside of a regular academic education, in which there is a reasonable amount of scientific education provided for, such as the general courses in chemistry, including qualitative and quantitative inorganic work, and the theory of organic work. A preliminary education of this

[1] See p. 208.

type, under proper guidance in the industry ought suitably to fit the individual to make a beginning."

In industry, experience in a laboratory has frequently been valued more highly than an advanced degree. Responsible positions have been attained by persons with only an undergraduate training. Yet a different point of view is rapidly coming to prevail with a growing conception of the importance of science to industry.

The committee on cooperation between universities and industry of the American Chemical Society recommends graduate work, and gives it preference over the suggested alternative of a fifth year of study added to the undergraduate curriculum. The committe reports[1] as its opinion, unanimously agreed to, "that it is desirable that such students as can spend five years in their training should add a year of graduate study at the close of the work leading to the bachelor's degree rather than continue a fifth year in work covered by a fixed curriculum. The training of such students in methods of research is considered more important than an increase in the number of formal courses of an undergraduate character. Some advanced course should, however, be taken by such students during the fifth year. It is further the opinion of our committee that four years is too short a time for the thorough training of a professional chemist."

In an address before the American Chemical Society in April, 1921, Mr. William J. Hale of the Dow Chemical Company insisted that "the possibility of a four-year trained chemist or chemical engineer, immediately after entering the chemical industries, being able to function in any other capacity than as a simple analyst is veritably an absurdity. Industrial research laboratories are now manned with a higher personnel, thanks to the period of depression which served to weed out near-chemists everywhere. When further assistance is desired we shall seek the best-trained men we can get. What is a thousand dollars more or less in salary to a man who has his doctor's degree or several additional years of study and research to his credit?

"Thus, of greatest benefit to the young chemist are courses in mechanical drawing, machine shop, testing materials, courses in calculus, in advanced physics, with emphasis upon thermodynamics and electrical theory; and finally, courses where practical studies are made of distillation, evaporation and filtration. In fact, it is not too cruel to state that those young men who plan to enter the chemical profession without thorough training in the principles

[1] Journal of Industrial and Engineering Chemistry, May, 1920.

of physics and engineering, such as are gained by a study of subjects outlined above, are building for themselves hazards innumerable, and it were far better for them and for the cause itself to keep off the course. . . .

"True, we can always make use of the newly fledged graduate as an analyst with the hope that he will develop, but what chances has he among those who have advanced training, and others coming in with more and more advanced training to their credit? . . .

"Those young men who contemplate chemistry as their life work should strain every effort to remain at the university for one to two years after graduation. This time should be devoted, primarily, to real investigation. The young chemist will thus develop as nowhere else is possible. Every phase of engineering that bears upon chemical industries should be studied with zeal. The principles of physics should be incorporated into the student's very being as a basic subject, not held aloof as something unnecessary. When these young men finally enter the world of industry, they will stand easily to the fore, and I assure you they will be given preference henceforth."[1]

Even when specialization is begun a knowledge of fundamentals and principles together with the ability to apply them to any concrete situation, the ability to comprehend quickly the essential points in a problem and to separate the significant from the unessential, are esteemed of greater value than the possession of an endless chain of facts. The line of chemistry chosen for specialization determines somewhat the kinds of industries in which the chemist will work; for example, inorganic chemistry prepares for work in metals or certain heavy chemicals, organic chemistry for coal tar products or certain pharmaceutical products, physical chemistry, especially colloids, for rubber or leather. Yet the range of specific possibilities in each line is a wide one and they constantly overlap.

Advancement in industry follows three main directions: into executive positions in the laboratory, into administrative work in the production departments, or into development and research. For executive and administrative work a preliminary knowledge of mechanics and engineering, economics, business management and cost accounting is an important asset; for research, fundamental training and much experience with the kind of problems involved. It is recognized increasingly that industry needs more able research chemists. Pure science is the forerunner and always pre-

[1] Journal of Industrial and Engineering Chemistry, May, 1921.

cedes industrial application. No one with the requisite aptitude for research can afford to forego a long period of fundamental preparation.

Government Laboratories. In the Federal Government service the title of junior chemist is applied to a beginning position to which the college graduate is eligible without practical experience. During the war a committee[1] composed of representative chemists from each of the scientific and technical bureaus of the Government met with the Civil Service Commission to determine what should constitute the minimum chemical training required of those entering the Service as junior chemists. The judgment of the committee was as follows: applicants must have completed a full four-year high school course or have completed 14 units of high school work accepted for college entrance, and, in addition, have graduated with a degree from a college or university with the completion of at least 118 credit hours, such a course to have included not less than 30 credit hours in chemistry, of which at least 6 must have been in general chemistry, 3 in qualitative analysis, 8 in quantitative analysis, and 8 in organic chemistry. The remaining 5 hours were to be elective with the candidate. It was hoped that the majority of applicants would present physical chemistry as the elective. An applicant just meeting these requirements would receive a rating of 70 per cent, which is the passing grade. Applicants with more than the prescribed work received higher ratings.

The general conclusion is that the best preparation for special fields of work is adequate training in the principles of chemistry and allied sciences.

[1] Journal of Industrial and Engineering Chemistry, December, 1919.

PART IV

FURTHER VOCATIONAL CONSIDERATIONS

Numerical Importance of the Vocation

The only information in regard to the comparative numbers of chemists engaged in the different kinds of industries is that compiled in 1917 by the U. S. Bureau of Mines[1] at the request of the Council of National Defense and carried out in cooperation with the American Institute of Mining Engineers and the American Chemical Society. Records were secured from 7,500 men engaged in the mining industry and from about 15,000 in the chemical industries. The results were classified according to the character of the work in which each one claimed proficiency; no attention was paid to any particular group in which the experience of the individual did not amount to more than one year, except when it was known that there were only a few experts in a certain branch. For many men an experience of more than one year was shown under several items so that the total number of index cards for 15,000 chemists approximate 28,000 or an average of 2 for each. While the items of the classification and the figures overlap, the results are valuable in suggesting the comparative absorption capacity for chemists in different industries. The classification is as follows:

CHEMISTS

(Classified by Chief Industrial Groups)

1. Acids, alkalies and salts	1,405
2. Alcohol and acetone	339
3. Ammonia oxidation	81
4. Analytical chemistry	3,808
5. Barium compounds	208
6. Cement and lime	584
7. Coal, gas, tar and coke	1,294
8. Dyes and textiles	775
9. Electrochemistry	769
10. Explosives (high)	962
11. Explosives (black powder)	150

[1] Albert Hill Fay, Preparedness Census, U. S. Bureau of Mines, Technical Papers No. 179.

12. Fats and soaps	834
13. Fertilizers	844
14. Foods	1,619
15. Glass and ceramics	262
16. Inorganic chemicals	532
17. Nitrogen (synthetic)	128
18. Organic chemicals (other than 2)	888
19. Paints and varnishes	577
20. Petroleum and asphalt	769
21. Pharmaceuticals	983
22. Pyrotechnics	42
23. Rubber and allied substances	494
24. Sugar, starch and gums	592
25. Water, sewage and sanitation	1,035
26. Wood products	368
27. Metallurgical chemistry	494
a. Alloys, ferrous	323
b. Alloys, non-ferrous	360
c. Aluminum and magnesium	127
d. Antimony, bismuth, cadmium	54
e. Chromium and manganese	82
f. Copper	379
g. Gold and silver	337
h. Iron and steel	1,415
i. Lead	209
j. Mercury	25
k. Nickel and cobalt	68
l. Platinum metals	75
m. Radium and uranium	99
n. Silicon and titanium	89
o. Zinc	255
p. Other metallurgy	126
28. Professors and instructors	1,285
29. Miscellaneous	1,130

a. 240 men not actually engaged in laboratory work but holding administrative positions such as secretaries, presidents, and treasurers of chemical companies.
b. 157 leather chemists.
c. 116 research chemists.
d. A number of dentists, editors, physicians, chemical engineers and consulting chemists.

A report of the investment in chemical education in the United States in 1920-1921,[1] which includes information concerning 417 institutions, reveals the following totals:

Approximate valuation of buildings and equipment	$28,230,784
Valuation of new buildings under construction and their equipment	$7,553,300
Funds received for chemical endowment during the year	$525,868
Cost of maintenance of chemical and chemical engineering departments (salaries, chemicals, supplies, services, etc.)	$7,739,970
Total number of students in chemistry (all courses)	
Graduate	3,643
Undergraduate	209,128

[1] Journal of Industrial and Engineering Chemistry, March, 1922.

Total number of students in chemical engineering (when separate department is maintained)	
Graduate	302
Undergraduate	5,585

ADVANTAGES AND LIMITATIONS OF CHEMISTRY AS A VOCATION

ADVANTAGES

Conditions surrounding work in chemistry vary greatly with the place of occupation, as is true in most fields of activity. Chemists point out some fundamental advantages which particularly attend their profession in general, however:

1. The great advantage of work in chemistry lies in its basic value to society. If the chemist is working in a laboratory for medical and related analysis and research she is contributing to the fundamental welfare of mankind in the help given in correct diagnosis, the control of treatment, and the discovery of laws for the preservation and restoration of health. If she is working in industry she is helping to perfect the production of the materials which civilization needs, with an opportunity to develop more satisfactory means of production and a better basis for industry. If she teaches, she is engaged in the vital work of producing the chemists of the next generation. In any position she has opportunity for enlarging the bounds of the science and increasing the fund of human knowledge.

2. The work incites and maintains a decided mental activity which is elsewhere too often difficult to acquire.

"Our Bureau is much more stimulating than most universities. The interests are more varied. We come into contact with the best scientists." *(Woman chemist, Bureau of Standards.)*

"There is always the fascination of the experimental. There is satisfaction in applying original ideas."

(Woman assistant professor of chemistry in a Medical School.)

From chemists in industrial laboratories there comes an emphasis on the chance to grow, to learn all the while. "The work utilizes one's best mental ability and therefore is a wonderful developer." *(Woman chief chemist in a paper manufacturing plant.)*

3. The associations of the chemist are stimulating. Industrial chemists emphasize this:

"There is inspiration in the work itself and in the association with highly educated and interesting people."

(*Woman research chemist in a company manufacturing photographic supplies.*)

"The chemists have the advantage of coming in contact with those holding the highest positions in a factory."

(*Woman chemist in a print factory.*)

"One gets a business man's point of view; contact with different classes of people which is always broadening."

(*Woman analyst in chemical manufacturing company.*)

A chemist in a hospital laboratory points out that "scientific work as a rule brings one into contact with a very fine and intellectual type of people. Superficiality and bluff do not produce results in this field and so are not common among those leading the profession."

4. The work is varied and active. Chemists feel that "it is vastly to be preferred to any sedentary desk job" and that it is "less confining than office work with more freedom for planning one's own work."

5. Hours are usually good, but vary a great deal in the different fields in which chemists are employed. In a medical laboratory they may be irregular since the nature of the work demands that all analyses be finished as soon as possible; sometimes there may be little work, at other times 11 to 12 hours a day for days in succession may be required. In general, chemists in laboratory work feel that their hours are more definite and that less overtime is necessary than in teaching.

6. The surroundings depend upon the kind of position. In an educational institution, there are all the associations and advantages of an academic environment. In a laboratory for medical and related analysis and research the surroundings are those of a hospital and medical interests predominate. Chemists who are interested in hospital work find an added advantage in this. Residence in a hospital has, however, also been found to be a disadvantage, for "one who lives in a hospital has little chance to meet people of her own social or intellectual standing."

An industrial laboratory may be located in an unpleasant and inaccessible part of the city where living conditions are isolated and unattractive and long distances intervene between the plant and satisfactory living quarters. Yet this limitation is not peculiar to chemistry positions and does not affect the immediate surround-

ings in the laboratory itself. It seems to industrial chemists to have its compensations also:

"Most of my schoolmates are teaching. I prefer my own work. Though the hours are long and the surroundings dirty yet I think there is more companionship and associations with a wider and more varied group of people. Many of the people are college graduates and quite a large proportion are post-graduates."

(Woman chemist in a soap manufacturing company.)

LIMITATIONS

The chief limitations which have been cited as attending work in chemistry are:

1. Since it is active work which requires close application and, in many instances, excessive standing, it is physically tiring. It has been suggested that with the advent of women into laboratories it may be demonstrated that much of the work can be done equally well and with far less fatigue when seated on a stool.

2. The work may be dirty, but to the interested chemist this is of slight moment—"Not clean, hard on clothes, but one can dress down to the job and forget that part of it."

3. The work may be dangerous, especially in organic laboratories. There is no evidence that this limitation has been of influence with women chemists, although it has made employers hesitate in some instances to admit women to their laboratories.

4. Scientific work is not highly paid. One must consider the work itself its chief reward.

5. Other limitations which have been indicated are that the work deals wholly with things, with people only indirectly; that except in teaching, vacations are short; that the high specialization necessary may lead to isolation from other people and other interests; that routine work may become stupid. A special consideration in the medical field is the character of materials analyzed: "If a person has a repugnance against blood and all fluids secreted from the body she should not take up this work."

Many chemists see no handicaps in their work except the limits of their own individual capacity. "The field is broad enough so that there need be no limitations." "The limitations are not of significance for one of good health and willingness to work for results." "No limitations for women of ability and will-power." The great majority of chemists comment that the work is inter-

esting, the associations with earnest, intelligent, hard-working people, the hours good, and the spirit of the associates and surroundings a rich reward in itself.

ADVANTAGES AND DISADVANTAGES FOR WOMEN

The advantages and limitations which have been considered are equally true for men and for women. The special limitations of women chemists are:

1. Their general lack of mechanical skill which has been particularly noted in industrial work. This is due in some measure to the fact that women have less physical strength, but chiefly to the differences in the environmental influences under which they have grown up, and to differences in training. This limitation can be overcome in part by providing help for work which requires great physical strength and for routine mechanical work. Mechanical skill can be acquired through proper laboratory instruction and through practical courses in physics, mechanics and mathematics.

On the other hand, women are skilled in delicate manipulation and attention to detail.

2. Women have proven themselves markedly conscientious, painstaking in their work, which is recognized in the general faith in women as analysts. There is the corresponding danger that women are apt to think of the little things and overlook the big ones—overemphasize detail and fail to recognize the larger implications and the main issues. This fault is probably due chiefly to lack of experience and its underlying virtue is a valuable one to retain while experience is gained.

On the other hand women usually have a broader background of general culture and wide interest which is increasingly recognized as an important basis for all scientific work. In itself it does not suffice, but as a foundation it is of growing importance.

3. A limitation frequently referred to is the one which women meet equally in almost every line of work—the traditional prejudice against them. It is perhaps more prevalent in chemistry than in some other fields because women are still newer in this work. Directors are skeptical of women's ability, there is a lack of confidence on the part of the employer, men do not want to work under women, there is a necessity of standing alone and for fighting one's way somewhat as yet, there is a preference for men—these are the forms in which the prejudice is usually met in the field of chemistry.

This limitation will diminish and disappear gradually with the accumulating evidence that women are demonstrating their ability to do good work.

4. There is a common doubt as to women's ability to do original thinking and a question as to whether they are thereby limited to the subordinate positions; such inability is variously attributed to inherent lack or to generations of training which did not tend to develop original thought. Striking instances have proven that this lack is at least not universal among women. With greater responsibility and more general adequate training we may hope to find it not a sex limitation.

5. Many women chemists in industry consider as a limitation the general taking for granted that they are not fitted for plant work. This limitation is probably based on the lesser physical strength, the lack of mechanical ability, the tendency toward detail and the prejudice discussed above. But in addition to all of these, there is a general feeling, largely chivalrous, that the plant is not a suitable environment for a woman, though this consideration does not apply in the case of operatives. Administration and management in industry are primarily man's work. The future development will probably indicate that in certain industries, at least, this need not in the nature of the case be true.

Women must face frankly their limitations and recognize their advantages, then with confidence proceed to develop their strength and to contribute honestly all their ability without striving to be what they are not, yet without resting content to do only what is expected of them. The opportunity is the same for women as for men if they attack it with optimism and the proper qualifications.

6. Many employers hesitate to include women among their workers because marriage so often takes them out of their vocation into homemaking and the training which they have secured in their experience is considered lost. It is, however, to be noted, as against this argument, that (1) a woman probably holds an individual position, on the average, as long and in some cases far longer, than does a man, who leaves, in the regular and accepted course of events, to accept promotion or a position elsewhere. (2) Training in chemistry is applied in homemaking (food, sanitation, purchasing, etc.) to the advantage of society as a whole. (3) As a vocation for married women to pursue, positions in chemistry hold no greater difficulties than do positions in many fields in which married women are working—business, social work, and the rest. (4) Chemistry offers a variety of opportunities for

independent work which can be adjusted to the convenience of the married woman, in her own laboratory for clinical analysis, for microscopic work, for pharmaceutical chemistry, or if she be economically independent, for pure research. (5) A number of women chemists have married into the profession, as in other fields, and are pursuing work in chemistry in collaboration with their husbands.

QUALIFICATIONS REQUIRED

In discussing the qualifications required for their work, chemists have stressed good health, good training, hard work, the primary requisites in any field. Other qualities which are important in all successful work and which chemists recognize also as essential to the right kind of "personality," are the ability to take responsibility, reliability, dependability; adaptability, resourcefulness, poise, tact; an understanding and consideration of others, the ability to do team work with associates, to get along with people—acquired if necessary; optimism, cheerfulness; to summarize in one phrase, —common sense.

Individual qualities which are repeatedly named as fundamental to work in chemistry are, in the order in which they have been emphasized, as follows:

1. Accuracy. This implies and is implied in the quality of honesty, absolute truthfulness, so primary in all scientific work. It means also an observation of details and attention to them, a keen perception and alertness, as well as exactness and neatness in measuring and handling materials and in recording reports. Accuracy is involved in what one chemist terms "a scientific conscience, which compels one to check results and eliminate the personal equation as far as possible." It is the quality of mind that does not rest content with accepting results as true because they are plausible.

2. Perseverance. Application, earnestness, concentration, determination if necessary, faithfulness, conscientiousness, thoroughness, patience, are all related to the quality of perseverance—"unfailing perseverance despite many discouragements," "a fortification against defeat," "ability to profit by mistakes."

The director of research in one of the large chemical companies has said that the first requisite of a chemist is perseverance, the second is perseverance and the third is perseverance.

3. Initiative. Scientific work requires independence of mind, ability to cope with new situations, the willingness to assume re-

sponsibility, lack of self-consciousness. "The best training a woman chemist can possibly have gotten at college is in being independent."

4. Self-confidence. Closely allied to initiative, confidence in one's ability, with no trace of conceit—self-encouragement must be present. "In no field is a lack of self-confidence a greater handicap"; "backbone to stick up for yourself once you know you are right."

5. Imagination. Particularly for research work is imagination, a certain amount of originality, a fair amount of ingenuity, emphasized. Ability to cope with a new situation, to apply basic principles to new methods, implies such imagination. For the teacher it is "the ability to transmute dry hard facts into something vital to the student."

6. Reasoning ability, clear, independent thought, an orderly mind which systematizes, the ability to interpret facts observed, to think clear through a problem—"a mathematical and scientific type of mind," is a very general qualification which in one form or another is emphasized by chemists as expressing a quality of mental attack needed for scientific problems. "A keenly analytical mind and good critical ability; an unusually retentive memory and the ability to correlate the facts with the problem."

7. Judgment. Discrimination, recognition of comparative values, choosing the best course of action (ability to decide whether speed or accuracy takes precedence in a given situation, for example), ability to recognize that negative results are valuable as well as positive ones, ability to interpret observed facts, to sift evidence judiciously—such judgment the chemist must constantly be ready to exercise.

8. Attitude toward work. Interest in chemistry is of course a primary requisite for professional achievement—"real interest in chemistry and its advances," "a genuine interest in the work and all that radiates from your own particular task." Such interest leads to an "acceptance of the work as a real profession" which is the only attitude that makes for progress. Real acceptance of the work as a profession will naturally bring about the elimination of personal interests, which is essential to the highest type of work. "Doing of the thing at hand well, intelligently, thoroughly and without commotion, and for its own sake rather than with its reaction upon one's personal interests in view." "To be successful to your own satisfaction as well as outwardly."

Interest, a professional approach, will eliminate the possibility

of routine work, for routine is not so much inherent in the character of a task as in the attitude of the worker.

The woman chemist must be sure that the attitude toward her work includes a "willingness to accept all conditions imposed upon men," the ability "to command respect from men co-workers, but absolutely to forget sex in work and not expect favors because one is a woman."

"The qualifications, therefore, for a successful woman chemist, over and above a thorough college course, appear to me as follows: First, she should be a good sport, ready to make the best of a trying situation if need be. Second, perseverance in her work, using her own initiative in difficult work rather than expecting the men to be given the hard jobs and feeling that the easy ones are hers by right. Third, enough of a sense of fair play to expect to have her work judged by the same standards as a man's."

(*Woman chemist's assistant in an organization for industrial research.*)

"A pleasing personality, a well developed sense of values with a sane realization of women's handicaps and advantages in the business world; a liking for the work that is confining, wearing and impersonal. She must have tact and be generally developed socially and for most positions have initiative and a mind for detail. She must be honest, of course."

(*Woman chemist in the textile testing laboratory of a mail-order house.*)

9. Skill with the fingers, mechanical ability, deftness in setting up apparatus, exactness of manipulation, ability to work easily and well with the hands as well as the head, are necessary qualifications for laboratory work.

While all these qualifications are desirable for any work in chemistry, there is undoubtedly a difference between the requirements for analytical and for research work. The analytical chemist must possess perseverance, extreme carefulness and mental honesty to a high degree. The research chemist must not only be a thorough chemist, but a fine enthusiast of vigorous and original mind, willing to accept numberless defeats, always ready to attack a problem with spirit and from new points of view.[1]

SALARIES

Rates of compensation for scientific work compare with professional rather than with commercial salaries and do not offer the

[1] See also pp. 31, ff., 45 ff., 54 ff.

primary compensation for this type of work. In teaching, salaries have been notoriously low, but have in the last few years been increased very generally and to a marked extent. Hospitals are able to pay only small salaries; medical research has been compensated usually at university rates. Industry has paid the largest salaries, but only in a comparatively small proportion of cases. The large number of routine chemical workers are paid at approximately the same rates as are clerical workers.

Educational Institutions. The increase in high school salaries[1] in the last few years is indicated in data recently compiled by the United States Bureau of Education, from which the following information is taken:

Salaries of High School Teachers
(United States)

Number of teachers represented		Average Salaries Amount		Per cent increase
1918	1921	1918	1921	
69,314	69,358	$1,099	1,678	52.7

Per Cent of Teachers Receiving

Less than $800		Over $1,200		Over $2,000		Over $2,400 in 1921
1918	1921	1918	1921	1918	1921	
29.1	2.5	34.0	80.4	6.3	27.1	13.3

Comparison of Salaries of Men and Women High School Teachers
(United States)

Average Salaries of Teachers

Men		Women		Per cent increase	
1918	1921	1918	1921	Men	Women
$1,363	$2,033	$963	$1,504	49.1	56.2

Average Salaries in 1921 of

Beginning teachers			Teachers with over 5 years' experience		
Men	Women	Both	Men	Women	Both
$1.572	$1,184	$1,297	$2,248	$1,755	$1,943

College and university salaries have been increased during the same period in at least equal proportion. They vary greatly in different kinds of schools. In a large and prominent middle western university the range is $1,600-2,400 for an instructor, $3,000-3,500 for an assistant professor, $4,000-4,500 for an associate professor, and from $5,000 up for a full professor. At another middle

[1] For tables showing the average salaries paid high school teachers in the United States in 1921, arranged in groups according to the size of the cities, see School and Society, February 18, 1922.

western state university the lowest salary for an instructor is $1,800.

A women's college of high standing in the East is operating on the scale of $800 to $1,000 for an assistant, $1,200 to $1,800 for an instructor, $1,800 to $2,500 for an assistant professor, $2,500 to $3,000 for an associate professor, and $3,000 to $4,500 for a full professor.

In a leading middle western college the scale is $1,000 for an assistant, $1,500 to $1,800 for an instructor, $2,250 to $3,150 for an assistant professor, $3,600 for an associate professor, $3,750 to $4,500 for a full professor.

The Bureau of Education has reported the following figures to indicate what increases in salaries of the faculties of state universities and colleges have taken place between the year 1915-1916 and the collegiate year of 1921-1922.[1]

Salaries in State Universities and Colleges

	Average Salary 1915-16	Average Salary 1921-22	Per Cent of Increase
Dean	$3,062	$4,250	38.8
Professor	2,400	3,392	41.3
Associate Professor	1,926	2,800	45.4
Assistant Professor	1,603	2,300	43.5
Instructor	1,184	1,800	52.0

The highest salary discovered in the course of this study as paid to a woman trained in chemistry and employed in an educational institution is $7,000, which is received by the head of a university department of home economics. Three other teachers' salaries reported were above $3,000; a woman full professor receives $5,000; one associate professor $4,500, a second, $4,000. The following table includes the salaries submitted by 50 women teachers of chemistry in colleges and universities.

Salaries of 50 Women Teachers in Colleges and Universities

	Ass't.	Instructor	Ass't. Prof.	Associate Prof.	Prof.	Total
Under $1,000	2					2
$1,001-$1,200	2	3				5
$1,201-$1,500	2	5	3	1	1	12
$1,501-$1,800	1	2	2	3		8
$1,801-$2,000		3	3			6
$2,001-$2,500			6	1	1	8
$2,501-$3,000		1		2	2	5
Above $3,000				2	2	4
	7	14	14	9	6	50

[1] School and Society, February 25, 1922.

Medical Laboratories. In laboratories for medical and related analysis and research the high salaries seldom exceed $5,000. The following table indicates the salaries of 39 women chemists working in this group of laboratories.

Salaries of 39 Women Chemists in Laboratories for Medical and Related Analysis and Research

	Technician	Chemist	Clinical Pathologist	Research Chemist	Total
Under $1,000	5	3			8
$1,001-$1,200	7	3	1	1	12
$1,201-$1,500	2		1	3	6
$1,501-$1,800	1	1	1	3	6
$1,801-$2,000			2	1	3
$2,001-$2,500		3			3
$2,501-$3,000				1	1
Above $3,000					
	15	10	5	9	39

Industry. A chemist of wide experience in industry would put $1,200 as the lower limit for a competent analyst, $1,500 as the very least that anyone entitled to be called a research chemist should receive, and $2,500 as the minimum for a chief chemist. The scale of salaries in his own laboratories runs far ahead of the figures given.

The yearly rates that prevail in one large and important chemical industry are approximately as follows:

Assistant $1,380, $1,500, $2,000
Analyst $2,500
Chemist $2,500, $3,000
Research Chemist, $3,000, $5,000 high, $10,000 extraordinary
Head of a Division, $4,000, $7,500 (for overseeing one whole plant)
Chief Chemist $10,000, $12,000

Ninety-seven women chemists in industry have reported their salaries as follows:

Salaries of 97 Women Chemists in Industry

	Analyst	Chemist	Research Chemist	Head of a Division	Chief Chemist	Total
Under $1,000	5		1			6
$1,001-$1,200	11		1			12
$1,201-$1,500	22	4	1		1	28
$1,501-$1,800	11	4	7	4		26
$1,801-$2,000	6		4	4	2	16
$2,001-$2,500	1		2	2	2	7
$2,501-$3,000	1					1
Above $3,000				1		1
	57	8	16	11	5	97

Government Laboratories. The salaries of 21 women chemists in Government laboratories, federal and state, which were reported for this study are:

Salaries of 21 Women Chemists in Government Laboratories

	Analytical Chemist	Research Chemist	Director of a Bureau	Library Research	Total
Under $1,000	1				1
$1,001-$1,200	4				4
$1,201-$1,500	4				4
$1,501-$1,800	5	1			6
$1,801-$2,000					
$2,000-$2,500	4		1	1	6
$2,501-$3,000					
Over $3,000					
	18	1	1	1	21

A study of the economic status of chemists in the Government service in Washington, ten educational institutions, and thirty-seven industrial firms made for the Commission on Reclassification of Salaries in 1919[1] brought out the following comparison:

Average Salaries of Chemists in the Washington Service, 10 Educational Institutions and 37 Firms

	Chemists in Washington	Chemists in 10 Educational Institutions	Chemists in 10 Educational Institutions and 37 Firms
Junior Aid	$1,164	$ 720	$1,254
Senior Aid	1,192	900	1,589
Junior Chemist	1,419	1,908	2,062
Assistant Chemist	1,738	2,878	3,334
Associate Chemist	2,264	2,991	3,888
Chemist	3,042	4,976	6,758
Senior Chemist	3,904	5,650	10,138

The salaries recommended by the Congressional Joint Commission for Reclassification of Salaries for work in chemistry were:

Junior Aid in Chemistry	$ 840 - 900 - 960 - 1,020 - 1,080 - 1,140 - 1,200
Senior Aid in Chemistry	$1,200 - 1,320 - 1,440 - 1,560 - 1,680 - 1,800
Junior Chemist	$1,800 - 1,920 - 2,040 - 2,160
Assistant Chemist	$2,400 - 2,520 - 2,640 - 2,760 - 2,880 - 3,000
Associate Chemist	$3,240 - 3,360 - 3,480 - 3,600 - 3,720 - 3,840
Chemist	$4,140 - 4,320 - 4,500 - 4,680 - 4,860 - 5,040
Senior Chemist	

[1] Journal of Industrial and Engineering Chemistry, December, 1920.

The Lehlbach Bill, H. R. 8928, which has been passed by the House of Representatives and is now under consideration by the Senate, provides for the division of the professional service of the Government into groups in which the rates of compensation shall be as follows:

Grade 1	$1,620, 1,740, 1,860, 1,980	
Grade 2	$2,100, 2,280, 2,460, 2,640	
Grade 3	$2,820, 3,060, 3,300, 3,540	
Grade 4	$3,720, 4,020, 4,320, 4,620	
Grade 5	$4,860, 5,160, 5,460	A higher rate may be authorized by law
Grade 6	$5,400, 6,000, 6,600	

MEANS OF SECURING A POSITION

Positions in chemistry, as in other fields of work, are secured in a variety of ways, and no specific rule of procedure can be laid down which will be infallible for every case. The usual means through which appointments are brought about are the following:

1. The largest number of first positions are secured through the chemistry department of the college or university in which the student has been getting her preparation and where her work is, therefore, well known. Many employers ask heads of college departments to recommend possible candidates for positions. The professors of chemistry naturally have wide contacts in the field also and frequently discover openings for promising students. In many instances the department keeps in touch with its students and recommends them for advanced positions after they have gained experience or further training or both.

2. Not only teachers but also other friends and acquaintances frequently recommend chemists for openings in connection with which they have some influence; so that chemists, especially with some experience, are frequently *sought,* particularly for important posts. For example, a former teacher now in an industrial plant has been glad to take on some of his own students; an acquaintance with the chief chemist of a plant has led to an opportunity to enter the laboratory; acquaintances through scientific societies have led to new appointments. Broad contacts are always valuable.

3. The chemist with limited contacts has, however, no reason for discouragement. For direct personal application is as good a method of procedure in seeking a position as can be recommended. Many chemists report that they have secured their openings on their own initiative by such application. This initiative makes its own good impression and the personal element is so

important a factor in successful employment that a direct conference is increasingly considered primarily requisite for both parties concerned in making an engagement.

4. There are a number of useful agencies which have been of great assistance in placing trained workers:

The college appointment bureau, in those institutions in which it has been established, is of important service to students and alumnæ seeking employment.

Collegiate bureaus of occupations have been established in ten cities throughout the country for the service of trained women.

The Chemists' Club maintains an employment bureau in New York City for placing chemists throughout the country. For some years a small number of women have profited from this service.

In some centers the local section of the American Chemical Society maintains an employment committee for the advantage of its members.

Teachers' agencies throughout the country have placed many teachers of chemistry, especially in public schools.

5. For public school appointments a civil service examination is frequently required as the first step in making application.

Federal government positions, and a large majority of state and municipal government positions are filled through competitive civil service examinations.

SUMMARY

Chemistry as a Vocation

The development of the science of chemistry and of its application in agriculture, in industry and in medicine has been so extensive and holds so much possibility for the future that there will be, without doubt, increasing vocational opportunities for the trained chemist. The extensiveness of the science and the limit in the numbers that can at present be absorbed into the vocation make it imperative that the very best preparation be secured by those now choosing chemistry as their field of life work.

Women have as yet entered this field in small numbers; they represent from 4 to 5 per cent of the total number of chemists in the United States. There have for many years been a few women who have pursued this science and the total achievement of women in chemistry is so considerable as to leave no doubt of their ability to contribute work of a high order.

Positions in Chemistry

In Educational Institutions. Superior teachers of chemistry are greatly in demand. For women this demand has had no limitations in schools of home economics, where they hold the most important positions; in high schools they have been favorably received, although for science teaching men are preferred when available. In the colleges and universities women have only in isolated cases been appointed to full professorships. The work is usually a combination of lecture, quiz and laboratory instruction and research. In the large universities the opportunities for research have been greater; in the colleges, the opportunities for more individualized teaching.

In Laboratories for Medical Analysis and Research. In hospital laboratories a great deal of analytical work is conducted in connection with diagnosis. While this has been largely bacteriological, chemical analysis is of rapidly growing importance. In some hospital laboratories there is a separate division of chemistry. A limited number of hospitals also have facilities and

endowment for research; this is usually true of the hospitals connected with medical schools.

Special institutions for medical research have been established, in some cases independently, in others in connection with medical schools or hospitals. In all of these research in physiological chemistry is included. Such research is also conducted in medical schools, schools of public health, schools of home economics, schools of agriculture, government laboratories, and some industrial establishments. There are no limitations for women in these laboratories except those of their own capacity.

In Laboratories for Industrial Analysis, Development and Research. Chemists begin their industrial careers usually in the control laboratory where materials used and products made are continuously analyzed. The lines of advancement are to executive positions in this laboratory, to research work or to development work —specific investigations whose results are tried out and applied in the plant. Some control laboratory and research positions also involve plant work. For control analysis and laboratory research work women have been employed in a representative range of industries and have proven their ability to give satisfactory service. For positions which require plant work women have not been considered suitable. This is evidently chiefly due to the lack of experience of employers with women chemists and a timidity in undertaking the experiment of employing them. In a few instances, where women have been chief chemists, the supposed limitations of physical inability, unsuitability for dirty work, inability to handle workmen, lack of mechanical ability, have been successfully overcome. There is every reason to expect that in some kinds of industry at least women will in the future successfully carry the forms of work which involve plant operations as well as those which are confined to the laboratory.

In Government Laboratories. More than a thousand chemists and allied workers are employed in Federal Government departments in laboratories throughout the country. State and municipal governments also employ chemists in public institutions, boards of health, public service commissions, and the like.

Women chemists have as yet availed themselves too little of the opportunities offered in the public service. Most of the government work is laboratory work and therefore holds neither real nor supposed limitations for women; the experience is excellent and the opportunity for important service a great one.

Chemistry in Related Fields. Various kinds of scientific work are largely chemical or dependent upon a knowledge of chemistry as well as of the immediate science concerned. Pharmacy is a specialized field of chemistry which offers to women better opportunity than they have as yet taken advantage of. Microscopy is an increasingly important method of analysis in chemistry and one which would seem peculiarly suitable for women. Assaying, the analysis of metals and their ores, and metallurgy, the art of manufacturing metals as well as the scientific knowledge of them, are closely related to pure chemistry. Bacteriology depends more and more upon a basis of chemistry, botanists trained in chemistry or chemists trained in botany are needed for the study of plant physiology. Dietetics is outgrowing its practical connotation and becoming a science based primarily upon physiological chemistry.

Women with training in chemistry may also usefully apply such training in special libraries; scientific journalism, abstracting and translating; secretarial work, and purchasing and selling.

TRAINING

For professional work in chemistry the undergraduate preparation should lay a broad foundation in a general education in which English is particularly emphasized; establish a thorough knowledge of the fundamentals of inorganic, organic and physical chemistry with adequate analytical work, and include advanced work in the related sciences, physics, mathematics and, if possible, biology.

The undergraduate should become informed as to the achievements and present applications of chemistry and should learn how to use library facilities—journals, reference books, and various sources of information concerning particular substances or processes. A reading knowledge of German and, if possible, of French must be acquired.

Graduate training is generally necessary for progress in work in chemistry. There are various opportunities to pursue graduate work as a paid research assistant or as incumbent of a fellowship or graduate scholarship. The person under whom graduate training is secured is a more important factor than the university chosen. The specific vocational requirements for work in particular fields indicate that the best preparation for professional work is adequate training in the principles of chemistry and allied sciences.

FURTHER VOCATIONAL CONSIDERATIONS

Numerical Importance of the Field. Available statistics indicate that the number of chemists in the United States is about 15,000; they are approximately distributed as follows: In educational institutions, 1,285; in industry, 11,387; in government laboratories, 1,198; miscellaneous, 1,130.

Advantages and Limitations of Chemistry as a Vocation. The chemist renders a fundamental service to society, in whatever field she may be applying her scientific knowledge. The work incites and maintains decided mental activity and offers opportunity for enlarging the bounds of human knowledge. The associations are stimulating, the hours are usually good, the work is varied and active, the surroundings, though varying in the location of each position, are inherently those of a laboratory.

The work of the laboratory is physically tiring; it may be dirty and in some cases dangerous; the money returns are not high. The work deals chiefly with materials, with people only indirectly, the necessary specialization may lead to isolation. Yet the only considerable limitations in this field of work for those who are interested in it, lie in the bounds of individual capacity.

Women have lacked the mechanical skill which is requisite for much of the work in chemistry, but have been admirably adapted to the delicate manipulations necessary; proper training can largely overcome the handicap. From lack of experience, women are inclined to overemphasize detail; their scientific training has in general lacked in thoroughness and comprehensiveness. On the other hand they are apt to be equipped with a better general education, which is increasingly recognized as an important background for scientific work. The doubt as to women's capacity for original thinking is being dispelled by the demonstrations of this capacity on the part of an increasing number of women. In the same way is traditional prejudice against women in chemistry gradually being overcome. The problem of the compatability of vocation and marriage offers no greater difficulty in chemistry than in any other field; in several specialized lines independent work in chemistry can be pursued which may be adjusted to the life of the married woman.

Qualifications Required. The qualities which have been discussed as necessary for success in the field of chemistry, have been summarized by a psychologist, Dr. Ruth Clark, as follows:

1. Mechanical ability and skill above the average.
2. A logical mind.
3. A keen enjoyment in working with details:
   a. To be observed.
   b. To be recorded.
   c. To be memorized.
4. Enjoyment in solving concrete detailed problems.
5. Physical health and endurance above the average.
6. Ability to work independently, without supervision.
7. Ability to grasp large purposes.
8. Ability to work intellectually, without emotional interferences of a personal or social nature.
9. A critical point of view towards self and work.

Salaries. Rates of compensation for scientific work compare with professional rather than with commercial salaries. Teaching salaries have increased notably in recent years; in laboratories for medical analysis and research, salaries are approximately on the same scale as in educational institutions. In industrial laboratories the range of salaries is greater and the average probably higher; the number of high salaries is limited, however. In government laboratories the rates of remuneration have been lower than in other fields; there is a present effort on the part of Congress to improve the classification and salaries of federal civil service employees.

Means of Securing a Position. Chemistry teachers in colleges and universities, friends and acquaintances in the profession are frequently instrumental in placing chemists. Personal application is an excellent method of procedure in seeking a position. Various agencies exist for placing trained workers. Civil service examinations are the usual means of entrance into the public service.

APPENDIX

Colleges and Universities in Which Women May Secure Graduate Training in Chemistry

UNIVERSITIES WHICH OFFER WORK IN CHEMISTRY LEADING TO THE DEGREE OF DOCTOR OF PHILOSOPHY

California
- Leland Stanford Junior University, Stanford University.
- *University of California, Berkeley

Colorado
- †University of Colorado, Boulder

Connecticut
- *[1]Yale University, New Haven

Illinois
- Northwestern University, Evanston
- *University of Chicago, Chicago
- †*University of Illinois, Urbana

Indiana
- Indiana University, Bloomington

Iowa
- †Iowa State College of Agricultural and Mechanical Arts, Ames
- †*State University of Iowa, Iowa City

Kansas
- *University of Kansas, Lawrence

Maryland
- *[1]Johns Hopkins University, Baltimore
- University of Maryland, College Park

Massachusetts
- Clark University, Worcester
- Radcliffe College, Cambridge

Michigan
- †*University of Michigan, Ann Arbor

Minnesota
- *University of Minnesota, Minneapolis

Missouri
- †University of Missouri, Columbia
- †Washington University, St. Louis

Nebraska
- †University of Nebraska, Lincoln

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* In schools whose names are starred, there is offered also an undergraduate curriculum in chemistry leading to the degree of Bachelor of Science, or Bachelor of Chemistry.

† In schools marked with a dagger, there is offered also an undergraduate course in chemical engineering.

[1] Undergraduate course not open to women.

NEW YORK
†[1]Columbia University, New York City
*Cornell University, Ithaca
†Syracuse University, Syracuse

NORTH CAROLINA
University of North Carolina, Chapel Hill

OHIO
†Ohio State University, Columbus
†University of Cincinnati, Cincinnati

PENNSYLVANIA
Bryn Mawr College, Bryn Mawr
†*University of Pennsylvania, Philadelphia
†*University of Pittsburgh, Pittsburgh

RHODE ISLAND
Brown University, Providence

TEXAS
†University of Texas, Austin

VIRGINIA
†University of Virginia, Charlottesville

WASHINGTON
†University of Washington, Seattle

WISCONSIN
†*University of Wisconsin, Madison

COLLEGES AND UNIVERSITIES IN ADDITION TO THE ABOVE WHICH OFFER WORK IN CHEMISTRY LEADING TO THE MASTER'S DEGREE [2]

ARIZONA
*University of Arizona, Tucson

CALIFORNIA
Mills College, Mills College
Pomona College, Claremont

COLORADO
Colorado College, Colorado Springs
†University of Denver, Denver

DISTRICT OF COLUMBIA
Trinity College, Washington

IDAHO
†University of Idaho, Moscow

INDIANA
†Purdue University, La Fayette

KANSAS
*Kansas State Agricultural College, Manhattan

KENTUCKY
*University of Kentucky, Lexington

LOUISIANA
†Louisiana State University, Baton Rouge

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[1] Course in engineering not open to women.

[2] Only those schools are included which are accredited by the Association of American Universities, the North Central Association of Colleges and Secondary Schools, or the Association of Colleges and Secondary Schools of the Southern States, and whose catalogues list fundamental courses in inorganic, organic and physical chemistry. See pp. 208, 215.

MAINE
†*University of Maine, Orono

MASSACHUSETTS
*Boston University, Boston
*Massachusetts Agricultural College, Amherst
†*Massachusetts Institute of Technology, Cambridge
Mount Holyoke College, South Hadley
Smith College, Northampton
Wellesley College, Wellesley
*Jackson College for Women, Tufts College

MISSISSIPPI
University of Mississippi, University

MONTANA
†*Montana State College of Agriculture and Mechanic Arts, Bozeman
University of Montana, Missoula

NEVADA
State University of Nevada, Reno

NEW MEXICO
†University of New Mexico, Albuquerque

NEW YORK
†*University of Rochester, Rochester
Vassar College, Poughkeepsie
Wells College, Aurora

NORTH DAKOTA
*North Dakota Agricultural College, Agricultural College
University of North Dakota, University

OHIO
Oberlin College, Oberlin
Ohio Wesleyan University, Delaware

OKLAHOMA
†Oklahoma Agricultural and Mechanical College, Stillwater
†University of Oklahoma, Norman

OREGON
University of Oregon, Eugene

PENNSYLVANIA
*Pennsylvania State College, State College
†*Swarthmore College, Swarthmore
*Temple University, Philadelphia

SOUTH CAROLINA
University of South Carolina, Columbia

SOUTH DAKOTA
South Dakota State College of Agriculture and Mechanic Arts, Brookings
University of South Dakota, Vermillion

TENNESSEE
†*Vanderbilt University, Nashville

TEXAS
†Rice Institute, Houston

VERMONT
*University of Vermont, Burlington

WASHINGTON
†*State College of Washington, Pullman

WEST VIRGINIA
West Virginia University, Morgantown

PRIZES AND GRANTS AVAILABLE FOR RESEARCH IN CHEMISTRY[1]

I. MEDALS AND PRIZES AVAILABLE FOR THE ENCOURAGEMENT OF RESEARCH

1. *Chemistry*

AMERICAN CHEMICAL SOCIETY, Chicago Section, R. J. Quinn, Secretary, 3314 West 67th Stret, Chicago.

Willard Gibbs Medal for eminent work in and original contributions to pure or applied chemistry. Established, 1911.

AMERICAN CHEMICAL SOCIETY, New York Section, 17 Battery Place, New York City.

William H. Nichols Medal, for meritorious research in organic chemistry. Established, 1902. Annually available $98.00.

GLASS CONTAINER ASSOCIATION OF THE UNITED STATES, 3344 Michigan Avenue, Chicago, Ill.

Awards (7) for theses submitted prior to June 10, to stimulate more general research along the lines of better preparation and packing of foods and beverages, and to increase our knowledge of changes induced by preparation or storage of such products. Established, 1920. Annually available $50 to $150.

SOCIETY OF CHEMICAL INDUSTRY, American Section, Allan Rogers, Secretary, Pratt Institute, Brooklyn, N. Y.

Grasselli Medal, for thesis presented before the Society and offering the most useful suggestions in applied chemistry. Perkin Medal, for the most valuable work in applied chemistry. Established, 1906.

2. *Science, unrestricted.*

ASSOCIATION TO AID SCIENTIFIC RESEARCH BY WOMEN, Dr. Lilian Welsh, Goucher Colege, chairman of the committee on the Prize.

Ellen Richards Research Prize of one thousand dollars for the best thesis written by a woman, on a scientific subject. This thesis must embody new observations and new conclusions based on independent laboratory research.

UNIVERSITY OF CHICAGO, Chicago, Ill.

Rosenberger Medal, for achievement in research in authorship, invention, discovery, unusual public service, or anything deemed of great benefit to humanity. Not limited to the University. Established, 1917. Annually available $100.

COLUMBIA UNIVERSITY, New York City.

Barnard Gold Medal, awarded on recommendation of National Academy of Sciences to any person who within the five preceding years has made a worthy discovery in physical or astronomical science, or such novel application of science as to be beneficial to the human race. Quinquennially available. Not less than $200.

[1] For institutional funds for research, restricted to use in the institution holding or administering them, see Bulletin of the National Research Council, Number 9, upon which the information included above is also based.

FRANKLIN INSTITUTE, 15 South 7th St., Philadelphia, Pa.

John Scott Medal Fund[1] medal and premiums awarded from time to time for useful inventions that will advance chemical, medical, or any other science, or promote the development of industry in any form. Established, 1816. Annually available, $4,000 or more.

HARVARD UNIVERSITY, Cambridge, Mass.

Bowdoin Prizes, for dissertations in any special field of learning. Two prizes for dissertations in science. Established, 1791. Annually available, $200 for each prize.

MARYLAND ACADEMY OF SCIENCES, Baltimore, Md.

Medals, awarded from time to time in recognition of scientific work and civic service.

II. GRANTS WHICH ARE MADE, UPON APPLICATION, TO INDIVIDUALS OR INSTITUTIONS TO PROMOTE OR ENCOURAGE RESEARCH

1. *Chemistry.*

AMERICAN ACADEMY OF ARTS AND SCIENCES, 28 Newbury St., Boston, Mass.

C. M. Warren Fund, for research in chemistry. Established, 1892. Annually available, $1,254.

AMERICAN MEDICAL ASSOCIATION, Council on Chemistry and Pharmacy, 535 Dearborn St., Chicago, Ill.

Fund of Committee on Therapeutic Research, used in connection with chemical investigations conducted by accredited research workers. Annually available, $2,000.

JOHN MCCORMICK INSTITUTE FOR INFECTIOUS DISEASES, 637 W. Wood St., Chicago, Ill.

W. A. Clark Fund, for research in physiological chemistry.

NATIONAL ACADEMY OF SCIENCES, Washington, D. C.

Wolcott Gibbs Fund, for research in chemistry. Established, 1892. Annually available, $308.

NATIONAL CANNERS' ASSOCIATION, 1739 H. St., N. W., Washington, D. C.

Grants for chemical, bacteriological and technical research relating to the manufacture of canned goods, systematic study of food poisons as applied to canned foods, but not limited to this phase, and the study of botulism.

YALE UNIVERSITY, New Haven, Conn.

Russell H. Chittenden Fund, for research in physiological chemistry. Established, 1915. Annually available, $192.

2. *Science, unrestricted.*

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, Burton E. Livingston, Permanent Secretary, Smithsonian Institution, Washington, D. C.

Permanent fund for grants for scientific research. Annually available, $4,000.

[1] This fund is administered by the Philadelphia Board of City Trusts.

AMERICAN PHARMACEUTICAL ASSOCIATION, 115 West 68th St., New York City.

Research fund to encourage investigation and research upon any subject relating to pharmacy or to the collateral sciences.

CARNEGIE INSTITUTION OF WASHINGTON, Washington, D. C.

Minor Grants for the continuation of work previously started and the encouragement of new work appropriated for 1922, $156,900.

CORNELL UNIVERSITY, Ithaca, New York.

August Heckscher Foundation, for the promotion of research. Established, 1920.

ELIZABETH THOMPSON SCIENCE FUND COMMITTEE, Dr. W. B. Cannon, Chairman, Harvard Medical School, Boston, Mass.

Elizabeth Thompson Science Fund, for use in the promotion of science through small grants, preference given to researches involving international cooperation. Established, 1885. Annually available, $1,200.

ENTOMOLOGICAL SOCIETY OF AMERICA, J. M. Aldrich, Secretary, National Museum, Washington, D. C.

Thomas Say Foundation, for the publication of scientific monographs.

GENERAL EDUCATION BOARD, 61 Broadway, New York City.

Appropriations are made to conduct educational research, using the word educational in its broadest significance.

INDIANA ACADEMY OF SCIENCES (adopted but not yet in operation)

NATIONAL ACADEMY OF SCIENCES, Washington, D. C.

A. D. Bache Fund, for research in physical and natural sciences. Established, 1870. Annually available, $3,323. Joseph Henry Fund, for original research in the sciences. Established, 1878.

NATIONAL RESEARCH COUNCIL, 1701 Massachusetts Ave., Washington, D. C.

Occasional grants for research in the natural and physical sciences.

NEW YORK ACADEMY OF SCIENCES, 77th St. and Central Park West, New York City.

Centennial Endowment Fund, for scientific research when it reaches the sum of $100,000.

Esther Hermann Research Fund, for research in any branch of science. Established, 1890.

RESEARCH CORPORATION, 31 West 43rd St., New York City.

Grants, for distribution to educational institutions, other organizations, or to individuals for the advancement and promotion of scientific enterprises.

ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH, New York City.

Grants are made for a single academic year ending June 30, unless otherwise agreed, and are limited largely to the support of investigations related to studies conducted at the Institute.

SMITHSONIAN INSTITUTION, Washington, D. C.

Smithsonian Institution Fund, from which small grants are sometimes made to scientific investigators.

Fellowships and Graduat

A large number of fellowships and graduate scholarship offered by organizations and universities are unrestricted as t subject and therefore available for chemistry. Many fellowship for research in medicine, in public health, in home economic and in agriculture may be devoted to biochemistry. For all suc fellowships see Graduate Fellowships Open to Women, compile by the Women's Educational and Industrial Union, Boston, an

FELLOWSHIPS AND GRADUATE SCHOLARSHIP

1. *Organization Fellowships.*

Awarding Institution	*Fellowships*	*Number*
American Association of University Women	Sarah Berliner Research and Lecture Fellowship, lasting one year Place of study unrestricted	1
National Research Council	Fellowships for research in chemistry or physics, lasting three years Place of study unrestricted	15 to 20
Commission for Relief in Belgium Educational Foundation	Graduate Fellowships for Belgian Universities, in chemistry and other subjects, lasting one year	8 (for 1922-1923)
American Council on Education	Scholarships for American students in French Universities, lasting one year	
	University of Nancy (Specifies that the first holder be a student in the Faculty of Science, who shall have completed three years of advanced study)	1
	University of Toulouse (American students will be especially interested in certain Institutes of the University, among them, Chemistry)	10

Scholarships Open to Women

published by the American Association of University Women. The following table gives information concerning fellowships and graduate scholarships which are definitely assigned to chemistry and are available for women students. Fellowships which are limited to graduates of the institutions awarding them are not included.

IN CHEMISTRY, AVAILABLE FOR WOMEN

Person to whom to apply	*Date when applications close*	*Requirements*	*Value*
Dr. Margaret Maltby, Barnard College, New York City	February 1	The Ph.D. degree or equivalent. Promise of distinction in research	$1,000-1,200
Secretary, National Research Council, 1701 Massachusetts Ave., Washington, D. C.	March 15	The Ph.D. degree or equivalent preparation. Marked ability	$1,800-3,500
The Fellowship Committee Commission for Relief in Belgium Educational Foundation, 42 Broadway, New York City	May 1	American citizenship, knowledge of French, college graduation, definite plans for study	12,000 francs plus tuition and traveling expenses
Dr. I. L. Kandel, 522 Fifth Avenue, New York City	May 20	Graduation from an accredited college, a fair knowledge of French, American birth	5,000 francs
Dr. I. L. Kandel, 522 Fifth Avenue, New York City	May 20	Graduation from an accredited college, a fair knowledge of French, American birth	2 offering tuition, board, lodging 8 offering free tuition

2. *University Fellowships.*[1]

Awarding Institution	*Fellowships*	*Number*
Brown University, Providence, R. I.	E. I. du Pont de Nemours and Company Fellowship	1
Bryn Mawr College, Bryn Mawr, Pa.	Helen Schaeffer Huff Memorial Research Fellowship in chemistry or physics	1
	Resident fellowship in chemistry	1
University of California, Berkeley, Cal.	E. I. du Pont de Nemours and Company Fellowship	1
University of Chicago, Chicago, Ill.	Edith Barnard Memorial Fellowship	1
	Hoskins Fellowship	1
	Joseph B. Lowenthal Fellowship	1
	E. I. du Pont de Nemours and Company Fellowship	1
	Gustavus F. Swift Fellowship	1
	Gypsum Industries Association Fellowship	1
Columbia University, New York City	Samuel Anthony Goldsmidt Fellowship for research in chemistry	1
	Plaut Fellowship for research in pharmacy abroad	1
Cornell University, Ithaca, N. Y.	Sage Fellowship in chemistry	1
	Graduate Scholarship in chemistry	1
	E. I. du Pont de Nemours Fellowship for research in chemistry	1
	Grasselli Fellowship for research in chemistry	1
	Graduate Scholarship in chemistry	1
	Gypsum Industries Association Fellowship	1

[1] These fellowships are assigned annually. In some cases reappointment of the sa incumbent is possible.

Person to whom to apply	*Date when applications close*	*Requirements*	*Value*
resident of the University	April 15	The bachelor's degree	$750
resident of the College	April 1	Advanced graduate work	$1,200
resident of the College	April 1	At least one year of graduate work	$810
ean of the Graduate Division	April 15	The bachelor's degree	$750
ean of the Graduate School	March 1	The bachelor's degree and one year of graduate study	$150
ean of the Graduate School	March 1	The bachelor's degree and one year of graduate study	$400
ean of the Graduate School	March 1	The bachelor's degree and one year of graduate study	$420
ean of the Graduate School	March 1	The bachelor's degree and one year of graduate study	$750
ean of the Graduate School	March 1	The bachelor's degree and one year of graduate study	$920
ean of the Graduate School	March 1	The bachelor's degree and one year of graduate study	About $1,200
ecretary of the University	March 1	The bachelor's degree	$650
ecretary of the University	March 1	The bachelor's degree in pharmacy	$500
ean of the Graduate School	March 15	The bachelor's degree	$400 and tuition
ean of the Graduate School	March 15	The bachelor's degree	$200 and tuition
ean of the Graduate School	March 15	The bachelor's degree	$750
ean of the Graduate School	March 15	The bachelor's degree	$750
ean of the Graduate School	March 15	The bachelor's degree	$200 and tuition
ean of the Graduate School	March 15	The bachelor's degree	About $1200

2. *University Fellowships*—(Continued)

Awarding Institution	*Fellowships*	*Number*
University of Illinois, Urbana, Ill.	Carr Fellowship for research in chemistry or chemical engineering	1
	Corning Glass Works Fellowship for research in Department of Ceramic Engineering	1
	E. I. du Pont de Nemours and Company Fellowship for research in chemistry	1
	U. S. Interdepartmental Hygiene Board	1
Iowa State College, Ames, Ia.	Gypsum Industries Association Fellowship	1
Johns Hopkins University, Baltimore, Md.	Grafflin Scholarship for research in industrial chemistry	1
	E. I. du Pont de Nemours Fellowships for research in chemistry	2
Leland Stanford Junior University, Stanford, Cal.	Teaching fellowships in chemistry	2
	John Maxson Stillman Scholarship in chemistry	1
Massachusetts Institute of Technology, Cambridge, Mass.	E. I. du Pont de Nemours and Company Fellowship for research in chemistry	1
	Ellen H. Richards Memorial Research Fund Scholarship for research in sanitary chemistry	1
	Ellen H. Richards Memorial Research Fund Assistantships in chemistry	2

Person to whom to apply	*Date when applications close*	*Requirements*	*Value*
ean of the Graduate School	March 1	Bachelor's degree. Candidate must be under 30 years of age.	Income of $10,000
ean of the Graduate School	March 1	Bachelor's degree and one or two years of graduate work	$800
ean of the Graduate School	March 1	Bachelor's degree and one or two years of graduate work	$750
Dean of Graduate School	March 1	Bachelor's degree and one or two years of graduate work	$600
ean of the Graduate College	April 1	Bachelor's degree	About $1200
resident of the University	April 1	Open to those who have already secured the doctor's degree or who have made a record at least equivalent to the requirements for this degree	$1,000
resident of the University	April 1	The bachelor's degree	$750
xecutive Head of Chemistry Department			$600
xecutive Head of Chemistry Department		Open to undergraduates or graduates	$150
ommittee on advanced degrees and fellowships	March 1	The bachelor's degree	$750
		Training equivalent to that required for the bachelor's degree	Tuition fee
ommittee on advanced degrees and fellowships	April 1	Training equivalent to that required for the bachelor's degree	$480-600 $240-300

2. *University Fellowships*—(Continued)

Awarding Institution	*Fellowships*	*Number*
University of Kentucky, Louisville, Ky.	Gypsum Industries Association Fellowship	1
University of Michigan, Ann Arbor, Mich.	National Aniline and Chemical Company Fellowships for research in organic chemistry	2
	E. I. du Pont de Nemours and Company Fellowship for research in chemistry	1
	Acme White Lead and Color Works Fellowship	1
	Frederick Stearns and Company Fellowship for research in pharmacy	1
University of Minnesota, Minneapolis, Minn.	E. I. du Pont de Nemours Fellowship for research in chemistry	1
	Shevlin Fellowships for research in chemistry	4
University of North Carolina, Chapel Hill, N. C.	Ledoux Fellowship	1
Ohio State University, Columbus, Ohio	E. I. du Pont de Nemours and Company Fellowship for research in chemistry	1
	Grasselli Company Fellowship for research in chemistry	1
University of Pennsylvania, Philadelphia, Pa.	The Woodward fellowship for research in physiological chemistry[1]	1
University of Pittsburgh, Pittsburgh, Pa.	Fellowships of the Mellon Institute of Industrial Research[2]	
Vanderbilt University, Nashville, Tenn.	Dudley Fellowship in chemistry	1
University of Virginia, Charlottesville, Va.	E. I. du Pont de Nemours and Company Fellowship for research in chemistry	1

[1] Incumbent continued indefinitely on good service.
[2] Number of fellowships, 1920-21, 48: number of fellows, 83.

Person to whom to apply	*Date when applications close*	*Requirements*	*Value*
Chairman of the Graduate School Committee	April 15	The bachelor's degree	About $1,200
Dean of the Graduate School	March 1	The bachelor's degree	$750
Dean of the Graduate School	March 1	The bachelor's degree	$750
Dean of the Graduate School	March 1	The bachelor's degree	$750
Dean of the Graduate School	March 1	The bachelor's degree	$500
Dean of the Graduate School	March 1	The bachelor's degree	$750
Dean of the Graduate School	March 1	The bachelor's degree	$500
			$300
Dean of the Graduate School	March 15	The bachelor's degree	$750
Dean of the Graduate School	March 15	The bachelor's degree and ability to conduct research	$750
Dean of the Graduate School	March 1		
Director of Mellon Institute	Irregular intervals		Varying
Head of the Department	June 1	The bachelor's degree	$300 and fees
Dean of the University		The bachelor's degree	$750

2. *University Fellowships*—(Continued)

Awarding Institution	*Fellowships*	*Number*
University of Washington, Seattle, Wash.	Columbia University Fellowship for advanced study in chemistry, mining and engineering	1
	E. I. du Pont de Nemours and Company scholarship	1
University of Wisconsin, Madison, Wis.	University Fellowship in chemistry	1
	Hollister Fellowship in pharmacy	1
	Fritzsche Brothers Fellowship in pharmacy	1
	Newport Chemical Company Fellowship in pharmacy	1
	Newport Turpentine and Rosin Company Fellowship in pharmacy	1
	American Pharmaceutical Association Fellowship	1
	E. I. du Pont de Nemours Fellowship	1
	National Fertilizer Association Fund ($2,000 for 3 years)	
	Paint Manufacturers' Association of the U. S. Fellowship	
Yale University, New Haven, Conn.	Honorary Fellowships in biochemistry	2
	Henry Bradford Loomis Fellowship in chemistry	1
	National Tuberculosis Association Fellowship in biochemistry	1

Person to whom to apply	*Date when applications close*	*Requirements*	*Value*
ean of the Graduate School	March 15	The bachelor's degree	$250
ean of the Graduate School	March 15	Open to seniors and graduate students who major in chemistry or chemical engineering	$350
egistrar of the University	March 1	The bachelor's degree	$500
egistrar of the University	March 1	Graduate rank	
egistrar of the University	March 1		$500
egistrar of the University	March 1		$1,000
egistrar of the University	March 1		$500
egistrar of the University	March 1		$250 $750
egistrar of the University			
egistrar of the University			$300
ean of the Graduate School	March 1	Candidacy for the Ph.D in organic or biochemistry	
ean of the Graduate School	Competitive examination in October	The bachelor's degree and at least one year of graduate study at Yale	Income of $10,000
ean of the Graduate School		Candidacy for Ph.D. in organic chemistry or biochemistry	$1,000

SCIENTIFIC, TECHNICAL AND OTHER PERIODICAL PUBLICATIONS OF INTEREST TO CHEMISTS

AMERICAN ACADEMY OF ARTS AND SCIENCES, Proceedings of The Boston, Mass.

Contain scientific papers dealing with mathematical and physical sciences, natural and physiological sciences, moral and political sciences.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, Proceedings of The Washington, D. C.

Contain the constitution of the Association and the summarized reports of seven annual meetings, from 1914 to 1920, with lists of officers, etc., together with references to *Science* for presidential and other addresses; also a membership list of 12,000 names and addresses together with specific scientific, professional or industrial connections.

AMERICAN DRUGGIST, The, and Pharmaceutical Record *Monthly* New York, N. Y.

Contains contributed articles, discussions, editorials, formulas, news of the trade, educational notes, news of professional and scientific associations.

AMERICAN DYESTUFF REPORTER, THE *Bi-weekly* New York, N. Y.

Devoted to the use and application of dyestuffs and the mechanical equipment incidental thereto.

Contains contributed articles on dyestuffs and related subjects with a technical section; reviews of recent literature, recent patents, trade notes.

AMERICAN ELECTROCHEMICAL SOCIETY, Transactions of The *Semi-annually* Bethlehem, Pa.

Contain original scientific papers presented at the semi-annual meetings of the Society.

AMERICAN FERTILIZER *Bi-weekly* Philadelphia, Pa.

Devoted to the commercial fertilizer and allied industries.

Contains articles on the fertilizer materials markets. "Chemists' Section" conducted by the American Institute of Fertilizer Chemists.

AMERICAN FOOD JOURNAL, THE *Monthly* Floral Park, N. Y.

The national magazine of the food trades.

Contains technical articles, news of scientific developments in food trades, food legislation; machinery and equipment; news of the food trades; markets, book reviews.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, Transactions of The *Annually* New York, N. Y.

Published by the Polytechnic Institute, Brooklyn.

Contain scientific papers presented at annual conventions.

Bulletin of the

Contains proceedings of the meetings, with reports of Committees on Chemical Engineering Education, on Patents, and on other subjects of interest to chemical engineers.

AMERICAN JOURNAL OF DISEASES OF CHILDREN

Monthly Chicago, Ill.

Published by the American Medical Association.

For the advancement of the knowledge and for publication of scientific investigation of the diseases of children.

Includes reports of studies of feeding and related subjects.

AMERICAN JOURNAL OF PUBLIC HEALTH

Monthly Chicago, Ill.

Official journal of the American Public Health Association.

Contains general and scientific papers and articles dealing with foods and drugs, sanitary engineering, industrial hygiene, public health administration; books and reports reviewed.

AMERICAN JOURNAL OF SCIENCE

Monthly New Haven, Conn.

Devoted to the physical and natural sciences with special reference to physics and chemistry on the one hand, and to geology and mineralogy on the other.

Contains original scientific articles; abstracts.

AMERICAN SOCIETY FOR TESTING MATERIALS

Proceedings of The *Annually* Philadelphia, Pa.

Contain technical papers, presenting results of experiments. Also reports of committees on ferrous metals; non-ferrous metals; cement, lime, gypsum and clay products; miscellaneous materials. And tentative standards, including tentative specifications, tests, methods and definitions for various materials.

AMERICAN VINEGAR INDUSTRY *Monthly* New York, N. Y.

Devoted to the interests of the cider, wine, malt, spirit-vinegar and allied industries, and describing the possibilities in manufacturing various commodities by using material and waste from the orchard, the vineyard and the forest.

Contains technical and scientific articles; market news.

AMERICAN WOOD-PRESERVERS ASSOCIATION, Proceedings of The

Annually Baltimore, Md.

Includes papers on processes of preservative treatment, on standardization of specifications for wood preservatives, and related subjects of interest to chemists.

BAKING TECHNOLOGY *Monthly* Chicago, Ill.

Published by the American Bakers' Association.

Devoted to the advancement of the baking industry, publishing the official notices of the American Bakers' Association and interpreting for bakers the work of the research laboratories of the American Institute of Baking.

Contains general and technical articles; trade items.

CARNEGIE INSTITUTION OF WASHINGTON, Publications of *Irregular* Washington, D. C.

Separately published bulletins and reports; also reports of investigations in chemistry noted in the Year Book of the Institution.

CEMENT, MILL AND QUARRY *Semi-monthly* Chicago, Ill.

Contains technical papers from cement, mill and quarry industries and from geologists in government departments, etc.

CHEMICAL ABSTRACTS *Semi-monthly* Easton, Pa.

Published by the American Chemical Society.

Contains abstracts of articles appearing in a wide variety of current American and foreign technical and scientific journals.

CHEMICAL AGE, A consolidation of the Chemical Engineer and the Chemical Age *Monthly* New York, N. Y.

Devoted largely to developments in industrial chemistry—materials, equipment, methods.

Contains informative articles on a variety of industrial subjects, editorials, news items and industrial notes.

CHEMICAL AND METALLURGICAL ENGINEERING *Fortnightly* New York, N. Y.

Contains original articles on chemical and metallurgical engineering, readers' views and comments, synopses of recent chemical and metallurgical literature, industrial news and notes.

CLEANING AND DYEING WORLD *Monthly* Chicago, Ill.

Contains general and technical articles, discussion, convention and legislative news, news of associations.

COLOR TRADE JOURNAL, THE *Monthly* New York, N. Y.

Contains articles on chemical technology of dyestuffs; abstracts from technical and scientific journals; digests of recent patents relating to dyes and textile chemistry.

COTTON OIL PRESS, THE *Monthly* Washington, D. C.

Official bulletin of the Interstate Cotton Seed Crushers Association.

A journal of research and education in oil seeds and their products, with "Chemists Section" containing contributed scientific articles.

CREAMERY AND MILK PLANT MONTHLY, THE *Monthly* Chicago, Ill.

Contains general, technical and scientific articles; reports of International Association of Dairy and Milk Inspectors; editorials, news of the trade.

DRUGGISTS' CIRCULAR, THE *Monthly* New York, N. Y.

Practical journal of pharmacy and general business organ.

Contains a section devoted to condensed statements of facts of interest to pharmacists taken from recent issues of pharmaceutical, chemical, and professional and technical publications.

DYESTUFFS *Monthly* New York, N. Y.

An informing periodical published by the National Aniline and Chemical Company in the interests of the mill management, the dyer and the colorist.

Contains abstracts from technical journals; occasional contributed articles.

GENERAL SCIENCE QUARTERLY

Nov., Jan., Mar., May Salem, Mass.

Addressed to teachers of science in the secondary schools.

Contains articles suggestive of interesting and stimulating ways of teaching science; reviews of scientific books and lists of contemporary scientific articles.

GLASS INDUSTRY, THE *Monthly* New York, N. Y.

Devoted to glass technology, engineering, raw materials and glass factory equipment and operation.

Contains contributed articles and news of the trade with divisions devoted to the laboratory and to technical consultation service.

INDIA RUBBER WORLD, THE *Monthly* New York, N. Y.

Contains contributed general and technical articles; section devoted to the interests of rubber chemists; news of the trade, patents relating to rubber; news of rubber markets.

INDUSTRIAL DIGEST, THE *Semi-monthly* New York, N. Y.

Digest of informative articles in 600 leading industrial magazines covering 30 industries; news of industrial inventions.

IRON AGE, THE *Weekly* New York, N. Y.

Contains general industrial and technical articles; editorials, trade information, mill news, markets and prices.

IRON TRADE REVIEW, THE *Weekly* Cleveland, O.

Devoted to the iron, steel, foundry and metalworking industries.

Contains technical articles, editorials, trade information.

JOURNAL OF AGRICULTURAL RESEARCH, THE

Irregularly Washington, D. C.

Published by authority of the Secretary of Agriculture with the cooperation of the Association of Land-Grant Colleges.

Contains scientific papers contributed by various bureaus in the Department of Agriculture and by experiment stations in the Land-Grant Colleges.

JOURNAL OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS, THE Hutchinson, Kan.

Contains scientific articles, reports of experiments, abstracts, notes of the industry.

JOURNAL OF THE AMERICAN CERAMIC SOCIETY

Monthly Easton, Pa.

With ceramic abstracts

Devoted to the arts and sciences related to the silicate industries.

Contains original papers and discussions, ceramic abstracts from a variety of American and foreign journals, book reviews.

JOURNAL OF THE AMERICAN CHEMICAL SOCIETY

Monthly Easton, Pa.

With which has been incorporated the American Chemical Journal.

Contains technological and scientific monographs grouped under (1) general, physical and inorganic, (2) organic and biological. Reviews of new scientific books.

JOURNAL OF THE AMERICAN LEATHER CHEMISTS' ASSOCIATION, THE *Monthly* Easton, Pa.

Contains original scientific papers; reports of research in leather chemistry; abstracts from other publications.

JOURNAL OF THE AMERICAN PHARMACEUTICAL ASSOCIATION, THE *Monthly* Easton, Pa.

Contains papers on technical and scientific subjects and reports on and bibliographies of pharmaceutical research; editorials; news of pharmaceutical societies; educational and legislative notes; book notices and reviews.

JOURNAL OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS, THE

Quarterly Washington, D. C.

Contains proceedings of the annual conventions of the Association including technical papers on a variety of subjects of interest to agricultural chemists.

Also published *Official and Tentative Methods of Analysis,* prepared by Committee on Revision of Methods.

JOURNAL OF BIOLOGICAL CHEMISTRY, THE

Monthly Baltimore, Md.

Official organ of the American Society of Biological Chemists.

Published by the Rockefeller Institute for Medical Research.

Contains original papers and reports on studies in biological chemistry.

JOURNAL OF CANCER RESEARCH, THE

Quarterly Baltimore, Md.

Official organ of the American Association for Cancer Research.

Contains articles bearing in any way upon the general problems of oncology; studies which approach the subject from the individual standpoints of statistics, immunology, pathology and inheritance, with contributions from biochemical laboratories.

JOURNAL OF DAIRY SCIENCE, THE

Bi-monthly Baltimore, Md.

Official organ of the American Dairy Science Association.

Devoted to the discussion of general and technical problems in the field of dairy science including such phases as dairy bacteriology, dairy chemistry, nutrition, butter making, market milk, cheese making, ice cream manufacture, condensed milk and milk powder, dairy cattle, breeding problems, dairy engineering, dairy management, dairy economics, and such other problems as are of vital importance to the dairy industry.

JOURNAL OF GENERAL PHYSIOLOGY, THE

Bi-monthly Baltimore, Md.

Published by the Rockefeller Institute for Medical Research.

Devoted to the explanation of life phenomena on the basis of the physical and chemical constitution of living matter.

Contains original scientific papers.

JOURNAL OF HOME ECONOMICS, THE

Monthly Baltimore, Md.

Published by the American Home Economics Association.

Devoted to the interests of home making, institutional management and educational work in home economics.

Contains papers of scientific and general interest; editorials; book reviews; bibliography of home economics.

JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY, THE

Monthly Easton, Pa.

Published by the American Chemical Society.

Contains scientific articles; activities of scientific societies; industrial notes and news; book reviews, market reports.

JOURNAL OF INFECTIOUS DISEASES, THE

Monthly Chicago, Ill.

Published by the John McCormick Institute for Infectious Diseases.

Contains reports of original investigations and articles on the biology and chemistry of the various pathogenic micro-organisms, and related subjects.

JOURNAL OF LABORATORY AND CLINICAL MEDICINE

Monthly St. Louis, Mo.

Contains original scientific papers; articles on laboratory method; editorials; directory of new laboratory books.

JOURNAL OF PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS, THE *Monthly* Baltimore, Md.

Contains original scientific papers; reports on research.

JOURNAL OF PHYSICAL CHEMISTRY, THE

Monthly except July, Aug. and Sept. Ithaca, N. Y.

Contains reports of studies and experiments in physical chemistry, reviews of new scientific books.

JOURNAL OF RADIOLOGY, THE *Monthly* Omaha, Neb.

Published by the Radiological Society of North America.

Contains reports from chemical, pathological and other laboratories; editorials, articles of general interest; has departments of technique, equipment, abstracts and reviews.

LEATHER MANUFACTURER, THE *Monthly* Boston, Mass.

Devoted to the science of manufacturing leather.

Contains technical articles; trade news; section on export situation.

MONTHLY ABSTRACT BULLETIN *Monthly* Rochester, N. Y.

Published by the Eastman Kodak Company.

Contains brief abstracts of articles from current periodicals; section on chemistry includes (a) Physical and Inorganic Chemistry, (b) Analytical Chemistry, (c) Colloid Chemistry.

NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA, Proceedings of The

Monthly Washington, D. C.

Official organ of the National Academy of Sciences and the National Research Council, for the publication of brief accounts of important current researches of members of the Academy and of the Council and of other American investigators and for reports on the meetings and other activities of the Academy and of the Council.

Contains sections devoted to chemistry, physics, astronomy, statistics and mathematics.

NATIONAL RESEARCH COUNCIL, Publications of The

Bulletin *Irregularly* Washington, D. C.

Contains contributions of general and special scientific interest.

Reprint and Circular Series

Irregularly Washington, D. C.

Renders available papers published or printed by or for the National Research Council.

Accounts of research, committee and other reports and minutes are published in the proceedings of the National Academy of Sciences.

PAINT MANUFACTURERS ASSOCIATION OF THE UNITED STATES Educational Bureau, Scientific Section, Circular Series

Irregularly Washington, D. C.

Contains reports of scientific investigations made at the instigation of or in the interests of the Paint Manufacturers Association.

PAINT, OIL AND CHEMICAL REVIEW *Weekly* Chicago, Ill.

Formerly Paint, Oil and Drug Review

Maintained in order to meet a need for an open forum for the discussion of scientific and practical problems of a chemical character, especially as related to the paint, oil, varnish, pigment, chemical and mineral dry color and gum industries.

Contains articles on technical and trade subjects with a section devoted to "The Chemists' Forum."

PAPER INDUSTRY, THE *Monthly* Chicago, Ill.

Educational journal of the paper industry.

Contains original articles on technical and scientific subjects of interest to the paper industry; trade news.

PAPER TRADE JOURNAL, THE *Weekly* New York, N. Y.

International weekly of the paper and pulp industry.

Contains news of the trade, editorials, abstracts, market news; and a section for the Technical Association of the Pulp and Paper Industry, devoted to the encouragement of original investigation and research work in mill engineering and the chemistry of paper, cellulose and paper-making fibers generally.

PHYSIOLOGICAL REVIEWS *Quarterly* Baltimore, Md.

Published by the American Physiological Society.

Contains concise but comprehensive reviews and comparisons of contemporary research; articles in which is summarized recent literature in physiology, using this term in a broad sense to include biochemistry, biophysics, experimental pharmacology and experimental pathology.

RADIUM *Monthly* Pittsburgh, Pa.

Devoted to the chemistry, physics and therapeutics of radium and radio-active substances.

Contains scientific articles, reviews and abstracts.

ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

Monographs of the *Irregularly* New York, N. Y.

Scientific papers which are so extensive or require such elaborate illustrations as to render them unsuitable for current periodical issues are published as separate monographs.

RUBBER AGE *Semi-monthly* New York, N. Y.

Contains technical papers; abstracts from technical and commercial literature; news of the industry; markets.

SCIENCE *Weekly* Garrison, N. Y.

Devoted to the advancement of science, publishing the official notices and proceedings of the American Association for the Advancement of Science.

Contains also original scientific papers; special articles; scientific books; notes and news.

SOIL SCIENCE *Monthly* Baltimore, Md.

Devoted to the broader outlook of the field of soil fertility.

Contains scientific papers dealing with the more important facts, observations, deductions and problems of soil biology, soil chemistry and soil physics.

SUGAR *Monthly* New York, N. Y.

Formerly American Sugar Industry

An English-Spanish technical journal devoted to sugar production.

Contains original articles on the problems and developments of the sugar industry; crop conditions; sugar markets; digests

of technical articles in current publications which are of interest to the sugar industry; patents relating to the sugar field, trade, notes and equipment items; a department, "The Chemist's Corner," contains notices of important chemical research of interest to sugar chemists.

TEXTILE AMERICAN, THE *Monthly* Boston, Mass.

Contains general and technical articles; mill news, reports of interest to the textile industries; occasional chemical articles, dealing especially with dyes.

TEXTILE COLORIST, THE *Monthly* Philadelphia, Pa.

Devoted to practical dyeing, bleaching, printing and finishing; dyes, dyestuffs and chemicals as applied to dyeing.

Contains technical and scientific articles; news and statistics of the industry, news of patents.

TEXTILE WORLD, THE *Weekly* New York, N. Y.

Contains general and special articles of interest to textile manufacturers; technical papers; news of the markets (goods, yarn, raw materials, financial), mill news, educational notes, business literature.

GOVERNMENT PUBLICATIONS

(*See Monthly Catalogue of United States Public Documents.*)

DEPARTMENT OF AGRICULTURE

Bureau of Animal Industry
Bureau of Plant Industry
Forest Service
Bureau of Chemistry
Bureau of Soils
Bureau of Entomology
States Relations Service
Office of Home Economics
State Experiment Stations
Fixed Nitrogen Research Laboratory

Bulletins, circulars, scientific and technical papers, reports.

DEPARTMENT OF COMMERCE

Bureau of Standards

Bulletins, circulars, scientific and technical papers, reports.

DEPARTMENT OF INTERIOR

The Bureau of Mines
Patent Office
Geological Survey

Bulletins, circulars, reports of investigations, technical papers.

DEPARTMENT OF THE NAVY

Bureau of Ordnance
Bureau of Yards and Docks

General publications; pamphlets.

DEPARTMENT OF THE TREASURY

Public Health Service

Public health bulletins and reports, and Hygienic Laboratory bulletins.

DEPARTMENT OF WAR

Chemical Warfare Service
Ordnance Department
Medical Department
General publications; pamphlets.

THE SMITHSONIAN INSTITUTION

International Catalogue of Scientific Literature

U. S. TARIFF COMMISSION

Reports

READING LISTS containing references to chemical literature

Reading list on Scientific and Industrial Research and the Service of the Chemist to Industry by Clarence Jay West, Director, Information Department, Arthur D. Little, Inc. Reprint and Circular Series, National Research Council, Washington, D. C. 1920.

List of periodicals abstracted by Chemical Abstracts, published by the American Chemical Society, Ohio State University, Columbus, O. 1921.

List of Publications of Biological Interest, compiled by Clarence Jay West, for the Rockefeller Institute for Medical Research, New York, 1918.

NATIONAL SCIENTIFIC SOCIETIES FOR CHEMISTS

American Association for the Advancement of Science
American Association of Biological Chemists
American Association for Cancer Research
American Association of Cereal Chemists
American Association of Textile Chemists and Colorists
American Ceramic Society
American Chemical Society
American Electrochemical Society
American Institute of Chemical Engineers
American Leather Chemists' Association
American Oil Chemists' Society
American Pharmaceutical Association
American Physiological Society
American Society for Testing Materials
Association of Official Agricultural Chemists
The Chemists' Club
Iota Sigma Pi
Kappa Mu Sigma
National Academy of Sciences
Sigma Xi
Society of American Bacteriologists
Society of Chemical Industry (American Branch)

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